A CENTRAL PACKING-PRECOOLING SYSTEM FOR CELERY

Marketing Research Report No. 869

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with
Florida Agricultural Experiment Station

ACKNOWLEDGMENTS

The research on which this report is based was conducted under the supervision of Earl K. Bowman and Joseph F. Herrick, Jr., Transportation and Facilities Research Division, Agricultural Research Service, U.S. Department of Agriculture.

Acknowledgment is made to A. Duda & Sons, Oviedo, Fla., and to their staff for their cooperation and assistance in conducting this research project.

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Washington, D.C. Issued March 1971

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 - Price 30 cents

A CENTRAL PACKING-PRECOOLING SYSTEM FOR CELERY

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SUMMARY

Most growers in Florida use "mule trains" to harvest and pack celery in the field. This harvesting and packing system requires many workers. A prototype handling system based on a central packing and precooling plant was designed and evaluated. A system engineering study was made of the central packing and precooling plant, and tests of system components were completed.

Components of the study included: (1) Mechanical cutting and harvesting in the field; (2) hauling celery in bulk from the field to the packinghouse and dumping into a large water tank at the packinghouse; (3) mechanical weigh-sizing celery stalks; (4) manual place-packing celery stalks into crates; (5) mechanical inplant handling with fork trucks; and (6) unit-load precooling.

Layouts are provided for weigh-sizing celery stalks with both electronic checkweighing equipment and monorail conveyor sizers. Final packinghouse designs utilizing either of the mechanical sizing methods required approximately 40 percent fewer workers than the mule train harvesting and packing system.

Labor costs per crate for the mechanical harvest and central packing system were 20.8 cents with electronic weight sizers and 21.6 cents with monorail conveyor sizers. Labor costs and equipment ownership and operating costs were 30.1 and 31.1 cents per crate, respectively. Total labor and equipment costs for the mule train system were 48.3 cents per crate, which meant a total savings per crate of 18.2 cents for the system using electronic sizing equipment and 17.2 cents for that using the monorail conveyor sizers.

PURPOSE AND BACKGROUND

In the late 1940's, records were obtained from several celery firms in Florida that indicated a range in field-work requirements (manual cutting, stripping, and stacking in field boxes) from 31 to 65 man-hours per 10,000 stalks. Washhouse labor (dumping field boxes, sorting and packing stalks, and precooling and shipping) varied from 21 to 47 man-hours per 10,000 stalks (*4*).[2]

In the washhouse system of harvesting and packing, celery stalks were manually cut, trimmed, topped, and placed in field boxes. These field boxes were then transported to the washhouse, temporarily stored, and dumped onto the packing belt. Workers stationed along the belt sorted the stalks for size and packed them into crates. These crates were then transported by chain conveyor into a single-layer hydrocooler for precooling.

Currently (1969), most celery growers in Florida harvest and pack celery in the field on a mobile packing vehicle, commonly referred to as a "mule train" (fig. 1).

Each grower owns one to 10 mule trains and can harvest and pack 2,000 to 3,500 crates per day on each vehicle. The annual output for indi-

[1] W. G. Grizzell has resigned from the Agricultural Research Service.

[2] Italic numbers in parentheses refer to Literature Cited, p. 26.

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FIGURE 1.—"Mule train" mobile packing vehicle in Florida.

vidual celery producers varies from approximately 300,000 crates to 2 million crates per year.

Workers on the ground preceding the mule train sever the celery stalk root with a knife, break unwanted outer petioles from the stalk, and place the stalk on the mule train wing conveyor (fig. 2). The conveyor transports celery to the front of the mule train where stalks are cut to a standard length of 16 inches and fall onto a central belt conveyor where they are spray-washed. Workers riding on the mule train pick up celery stalks from the conveyor and pack them into wirebound crates (fig. 3). Packed crates are then conveyed to the end of the mule train and are stacked on field trucks for transportation to the precooler. The steps involved in cutting, packing, and transporting celery to the precooler under the mule train system are shown in figure 4.

Many workers are required for the mule train system because of the manual work involved in each operation. A study by Brooks (*3*) found that labor requirements to cut, pack, and haul to the precooler varied from 0.36 to 0.45 man-hour per crate. The older washhouse method required about 35 percent more labor than the mobile packing plant, or mule train method.

A systems engineering study was made of the celery harvesting, handling, and packing operations, and a new handling system was designed based on a central packing and precooling plant. A feasibility study was made of this system and of systems in which packing was done in the field. The study indicated the central packing-precooling plant offered the greater potential for economies.

Full use of the economic potential of the central packing-precooling plant system is made only if the celery is harvested mechanically, hauled in bulk to the packinghouse, mechanically sized, and precooled in unit loads (stacks of 32 crates).

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FIGURE 2.—Workers cutting celery stalks and placing them on the wing conveyor.

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FIGURE 3.—Workers packing celery in wirebound crates on mule train.

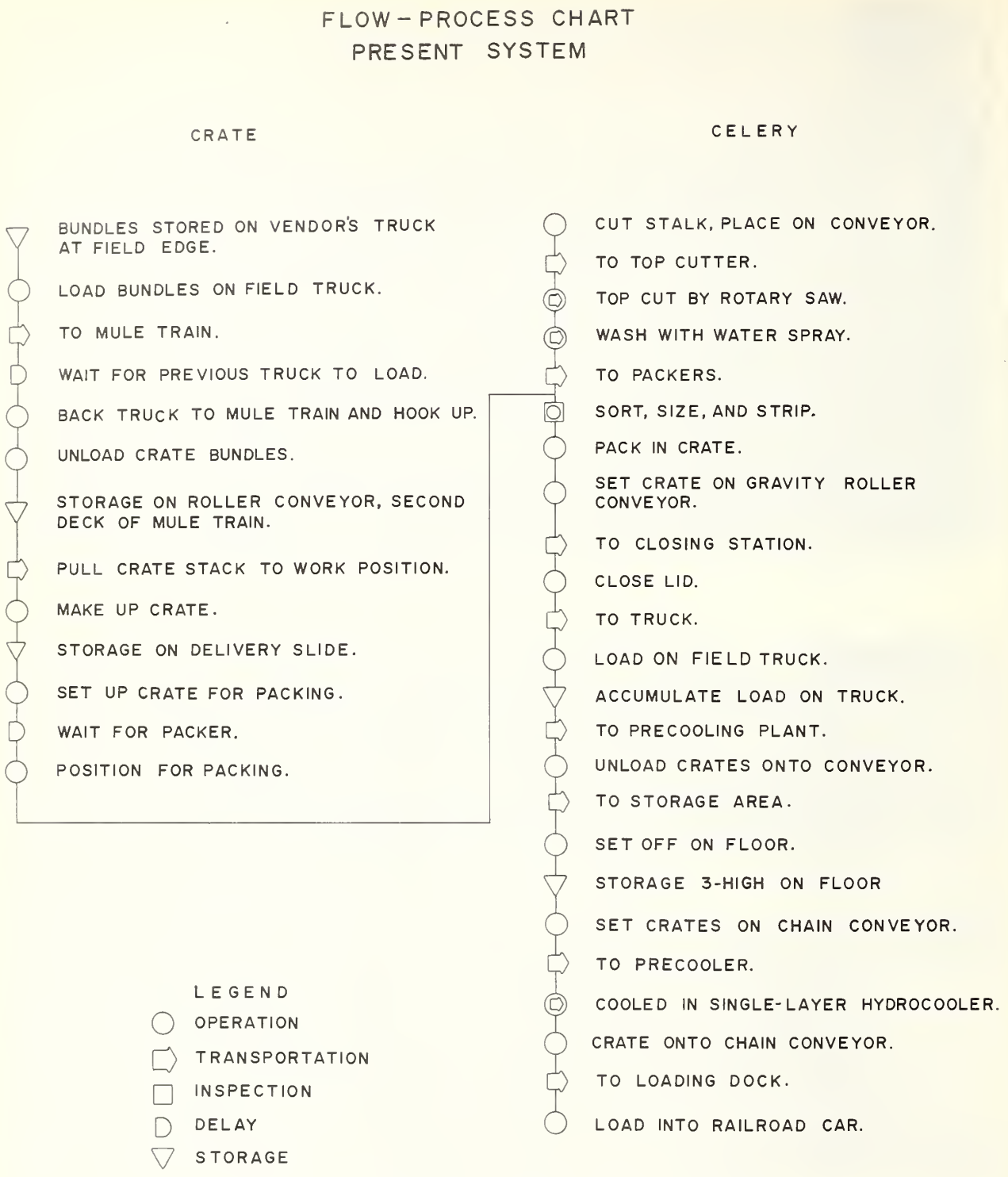

FIGURE 4.—Flow-process chart of mule train packing system.

FIELD OPERATIONS

Mechanical Harvesting

In a research project at the University of Florida, Beeman (*2*) developed functional specifications for a mechanical celery harvester. A research vehicle was built to test several design possibilities in the field.

The harvester developed and tested by engineers at the University of Florida was a one-row machine that cut 134 celery stalks per minute. Commercially built one-row harvesters of this design should cut 150 stalks per minute. A two-row harvester at this same rate will cut 300 stalks per minute.

Also, several mechanics and engineers working for celery growers in Florida independently developed and tested mechanical celery harvesters of different design.

Most of the harvesters developed to date have a stationary knife blade placed at an angle of 60° to the line of travel. The blade makes a smooth, clean cut, and the stalk is lifted from the ground by two opposing grip belts. These belts elevate the stalks and carry them past a top trimmer. The stalks are then dropped onto a cross belt conveyor, conveyed to one side of the machine, and dropped into a bulk trailer or field truck.

Two of the two-row harvester machines will be needed to cut celery for a packinghouse designed to pack 1,000 crates per hour. These machines, which cut 300 stalks per minute each, will cut approximately 1,090 crates of celery per hour. Because of mechanical breakdown possibility, a third harvester machine should be kept in reserve.

Bulk Hauling From Field to Packinghouse

Cooperative tests between engineers from the U.S. Department of Agriculture, University of Florida, and a Florida celery grower were made to evaluate depth of fill in a bulk trailer. Celery stalks were manually cut and trimmed to a length of approximately 16 inches. The stalks were carefully stacked in oriented arrangement on the floor of a trailer in depths of 2, 3, and 4 feet.

Test results indicated there was no increase in frequency or severity of stalk damage at different depths or locations within the trailer. In these tests, 41.7 percent of the stalks received no damage; however, 16.6 percent received minor bruising and scuffing (not scored against quality). One marketable petiole was cracked on 35.4 percent of the stalks and 5 percent had other minor scoreable damage. Major scoreable damage occurred on 1.3 percent.[3]

Drop tests to measure celery resistance to damage were conducted by Beeman (*1*). Results of these tests indicate celery can be dropped 6 inches with no damage. However, they indicated that 10 percent of the stalks have one or more cracked petioles if the stalk is dropped 12 inches; at 24 inches, 40 percent of the stalks have cracked petioles; at 36 inches, 80 percent.

It is, therefore, desirable that the stalk be dropped as short a distance as possible in the bulk trailer loading system. Also, the harvester cutting knife should be set low enough so three or more unmarketable petioles[4] remain on the stalk during the trip from the field to the packinghouse. These petioles cushion the stalk and absorb the damage that may otherwise be done to the marketable petioles.

Based on these results, a trailer 20 feet long, 7 feet 6 inches wide, and 4 feet deep was built and field tested in conjunction with a mechanical harvester. The trailer bottom was constructed so that it could be lowered during the filling operation to minimize the distance that the celery stalk dropped. Also, the trailer was designed to be self-unloading at the packinghouse. The trailer side pivots outward as the trailer body tips toward the dump tank. Celery

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[3] Scoreable damage is damage that Federal-State inspectors score against quality. Minor scoreable damage was defined as one cracked petiole or two badly scuffed petioles. Major scoreable damage was defined as two cracked petioles or three or more badly scuffed or bruised petioles.

[4] Petioles normally removed from the stalk before marketing because of size, shape, or color.

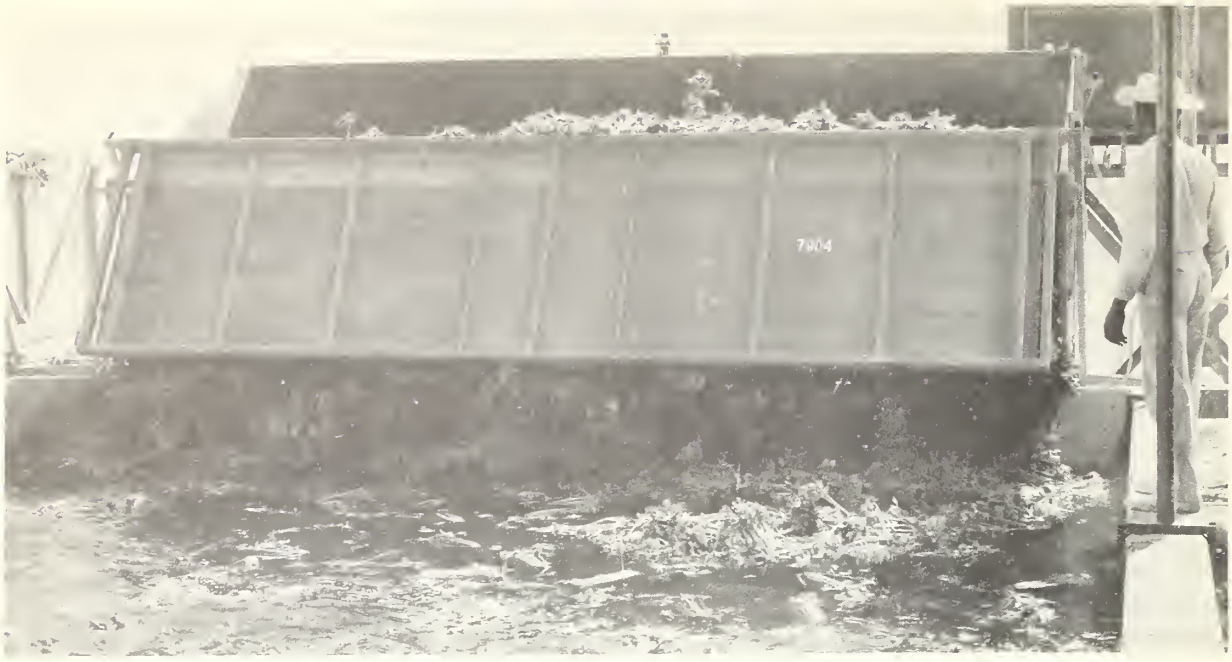


FIGURE 5.—Bulk trailer dumping celery into water tank.

stalks within the trailer slide out en masse and drop into the water of the tank (fig. 5).

Another evaluation of celery-stalk injury with the bulk trailer showed even less handling damage than in the first test. In these tests, 56.7 percent of the stalks received no damage. The rest of the stalks had some scuffing, bruising, and cracking of petioles, but only 8.7 percent of the stalks received minor scoreable damage and 1.3 percent major scoreable damage.

A trailer with dimensions specified (p. 5) holds approximately 3,000 stalks of celery and takes 11 minutes to fill including allowances for possible delays and turn-around at the end of the field.

Travel time to and from the packinghouse for a tractor towing three trailers is 48 minutes with an average one-way distance of 6 miles. The trailers can be unloaded at the packinghouse in approximately 6 minutes.

At these rates, six tractors each towing three trailers are required to move celery to a packinghouse at a rate of 600 stalks per minute.

PACKINGHOUSE DESIGN

The handling methods in the mechanical harvesting and packing system are different from those for the mule-train packing system. Manual handling has been eliminated where practicable, and provisions have been made for mechanical bulk handling. Steps involved in mechanically harvesting celery and packing in a central packinghouse are shown in figure 6.

Two packinghouse layouts are included. Both provide for a capacity of 1,000 crates packed per hour, but the equipment specified to mechanically size celery stalks differs. Each layout is described, equipment requirements are listed, and the operations are explained. Since much of the equipment and many of the operations are the same for both layouts, only those operations that differ are described in detail in connection with the second layout. Either of the layouts fits the overall packinghouse floor plan shown in figure 7.

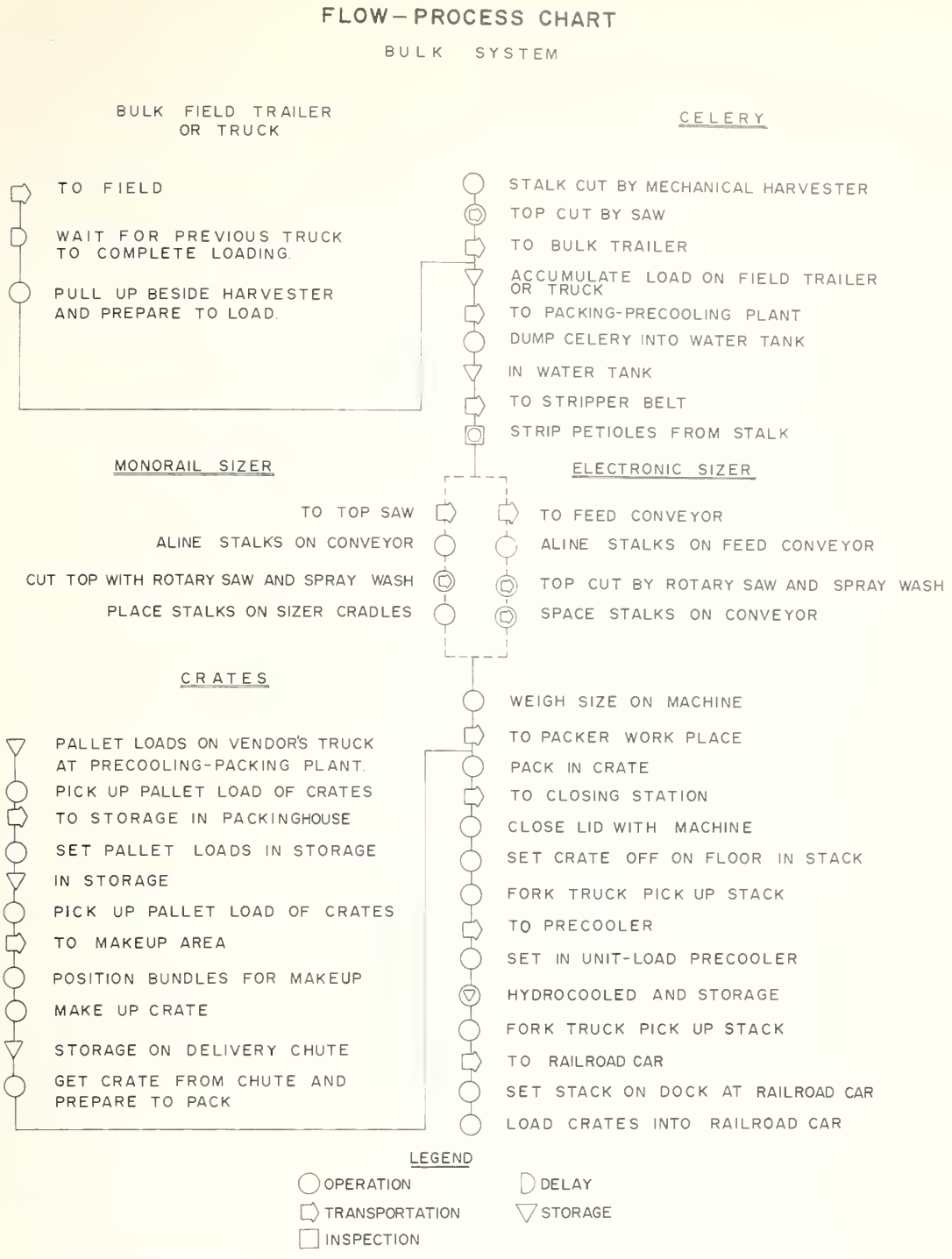


FIGURE 6.—Flow-process chart of central-packinghouse system.

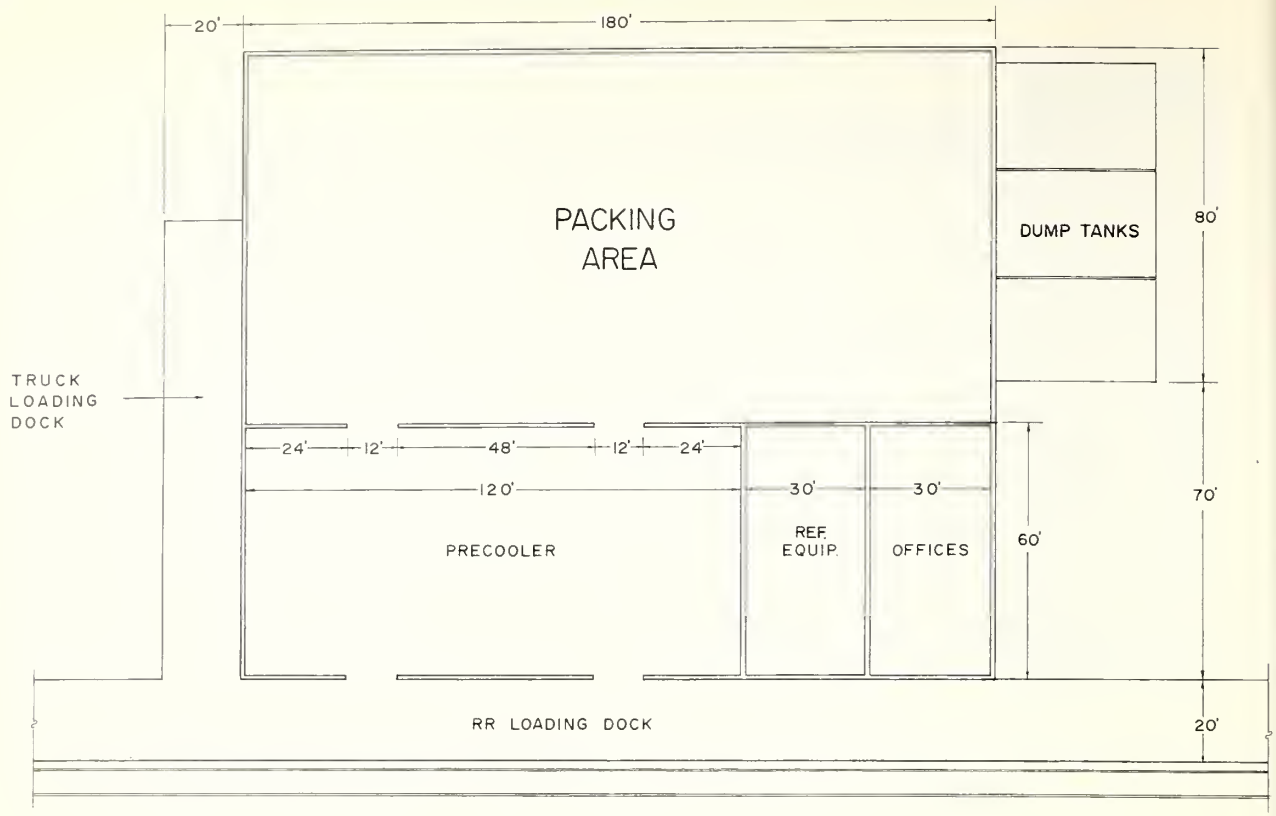


FIGURE 7.—Packinghouse floor plan.

Packing-Line Layout With Electronic Sizing Equipment

The packing-line layout designed to use electronic sizing equipment is shown in detail in figures 8 and 9. Celery stalks are dumped into one of three bulk receiving tanks, each feeding onto a processing line. Outer petioles are removed, and the stalks are cut to a standard length, washed, separated into size classifications, and packed into either wirebound crates or corrugated cartons. The filled containers are precooled and stored in refrigerated rooms to await shipment.

Equipment requirements

The items of equipment together with the quantity required for this layout follow:

Item No.	*Quantity*	*Description*
1	3	Dump tank (water), 26-×40-×10-ft., with flat bottom, and two 5-hp. pumps to pump water from sump on output end of tank to dump end of tank to create flow of water to move celery to feed-out conveyor.
2	3	Mesh-belt feed-out conveyor, 25-×15-ft., inclined 20° into water tank. Speed 10 f.p.m.
3	6	Cross-feed belt conveyor, 36-in.×10-ft. Elev. 69 in., speed 20 f.p.m., to feed celery stalks onto stripper belts.
4	3	Return-flow stripper belt conveyor, consisting of one 48-in.×22-ft., one 36-in. ×25-ft., and one 24-in.×25-ft. belt conveyors and one 2½-ft. R metal rod 180°-turn conveyor. Elev. 56 in., speed 70 f.p.m. Metal deflectors to deflect stalks from 4- to 3-ft. belt and from 2- to 3-ft. belt. Stalks separated on 3- and 2-ft. belt by 5-in.-high metal partition.
5	3	Trimmed-stalk-removal conveyor consisting of one 18-in.×48-ft. belt for center stripper line and two 18-in.×50-ft. belts for off-angle lines. Elev. 69 in., speed 70 f.p.m.
6	6	Platform, wood, 3-×40-ft. Elev. 24 in. For workers at stripper belt.

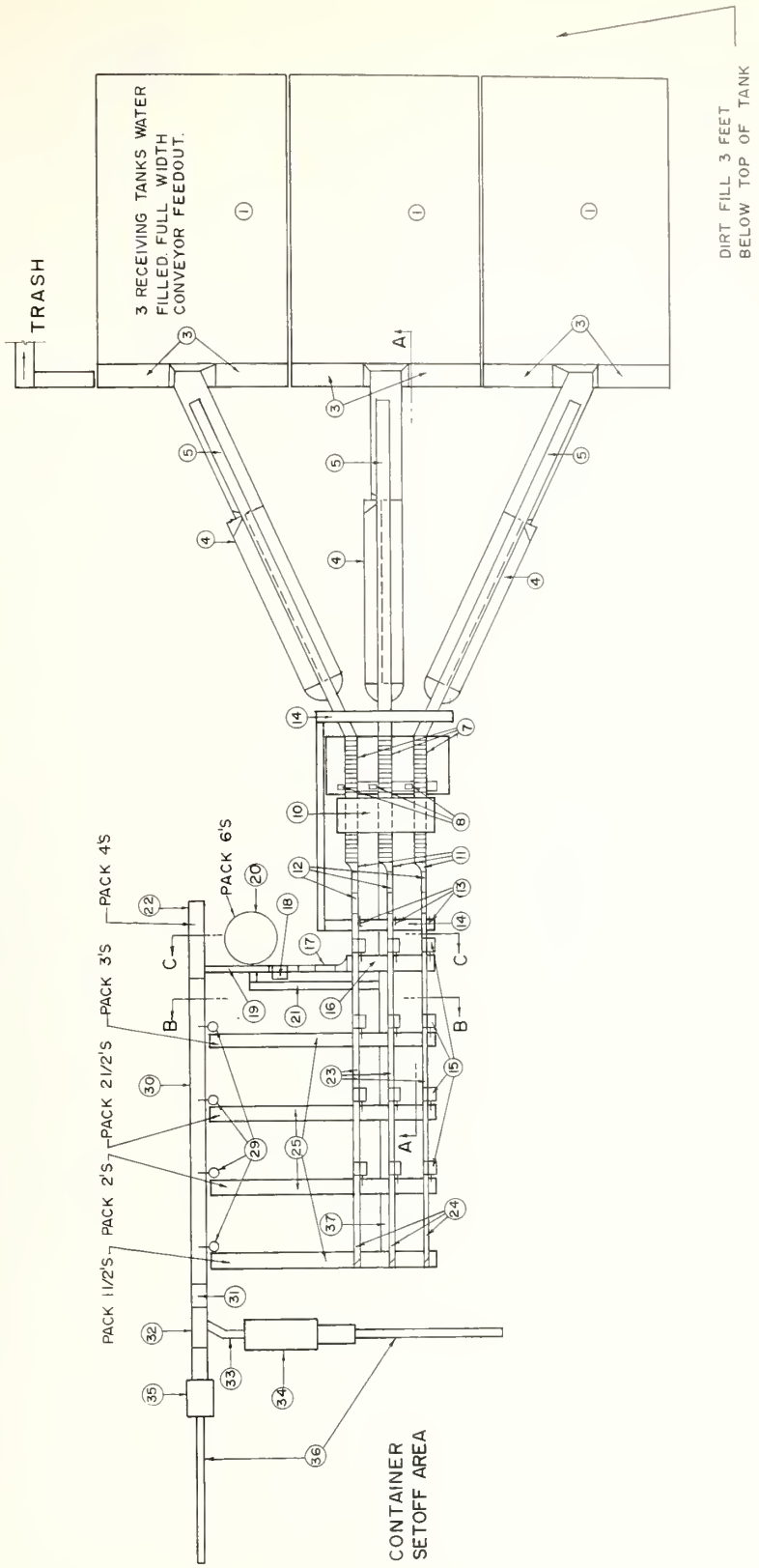
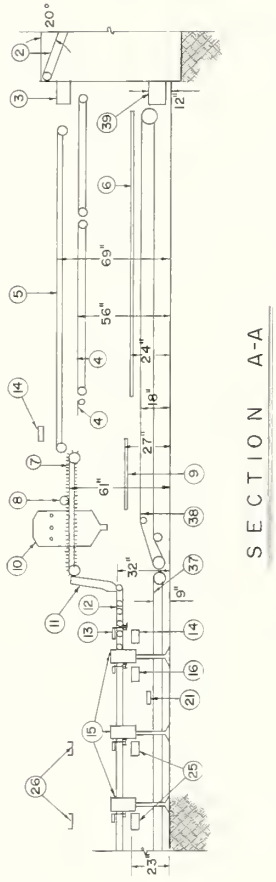
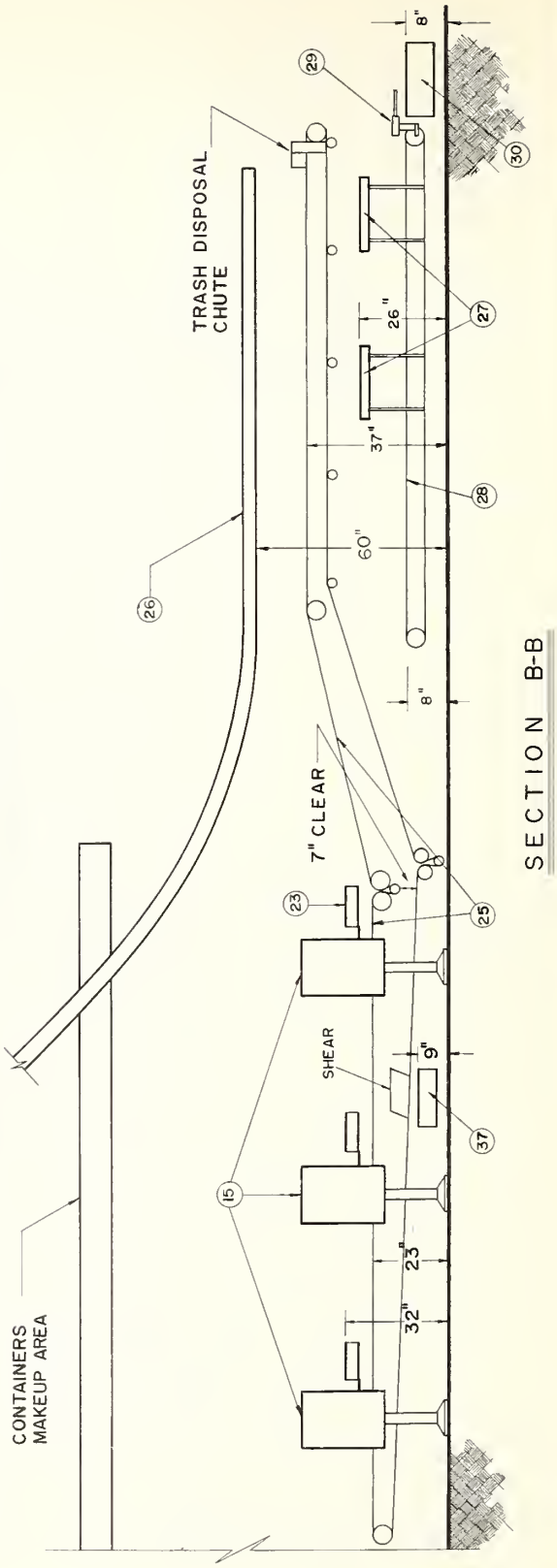


FIGURE 8.—Packing-line layout for electronic sizing equipment. (See figure 9 for elevations of sections and p. 8 for identification of numbered parts.)



SECTION A-A



SECTION B-B

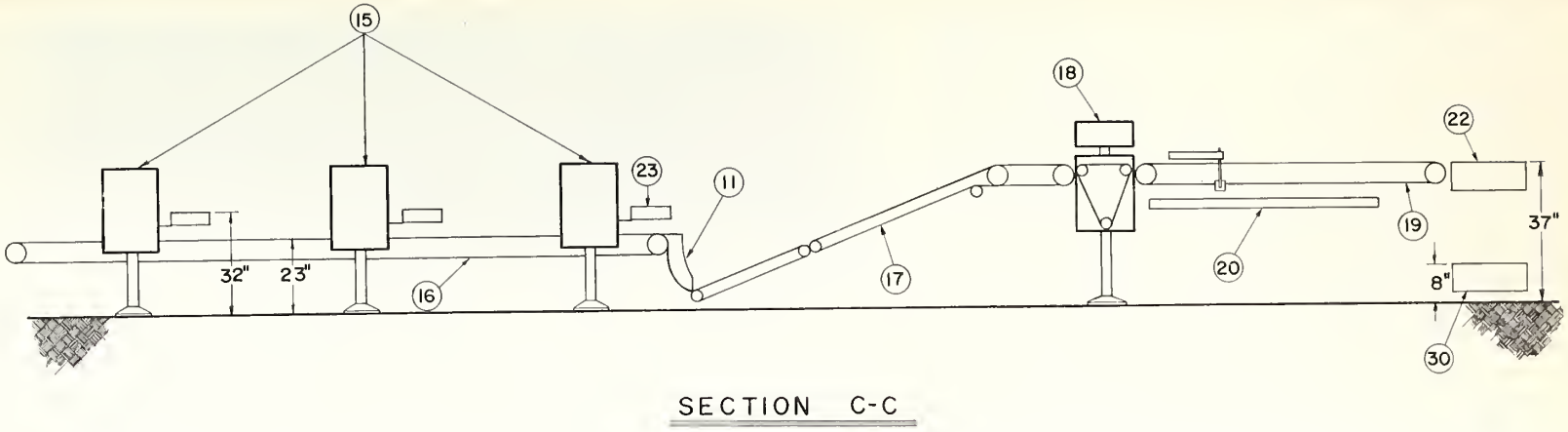


FIGURE 9.—Elevations of sections of packing-line layout shown in figure 8: A-A, Stripper belt, washer, and electronic sizers; B-B, packing belt and electronic sizers; C-C, packing area for stalk sizes Nos. 4 and 6. (See p. 8 for identification of numbered parts.)

Item No.	Quantity	Description
7	3	Mesh-belt conveyor, 20-in.×17-ft., with 1-in. high × 6-in. wide rubber spacer flights at 6-in. centers. To transport celery stalks past topping saw, through spray washer, to stalk-spacing conveyors. ½-in. mesh, elev. 61 in., speed 100 f.p.m.
8	3	Circular saw, 15-in. dia., with smooth or serrated blade. To cut stalks to standard length of 16 in.
9	1	Platform, wood, 8-×27-ft. Elev. 27 in. For workers at mesh-belt conveyor.
10	1	Washer, overall dimension of 5×13 ft. Water spray from full-cone nozzles onto top, sides, and bottom of celery stalks. Contained in stainless steel housing with water drain at bottom.
11	4	Celery-drop chute, 3 attached to end of mesh-belt feed conveyor (No. 7) and one attached to sized-stalk conveyor (No. 16).
12	3	Stalk-spacing belt conveyor, 6-in.×9-ft., consisting of 3 sections each 3 ft. long, operating at 267, 350, 415 f.p.m., elev. 32 in.
13	3	Photoelectric cell with stainless steel reject paddle to divert stalks too closely spaced.
14	1	Stalk-return belt conveyor for stalks rejected from main sizer line because of too close stalk spacing. Stalks returned to head of stalk feed conveyor for workers to place on the feed conveyor, consisting of 18-in.×15-ft. belt, at 23-in. elevation, followed by right-angle 12-in.×29-ft. conveyor inclined to meet 18-in.×18-ft. belt conveyor at 80-in. elevation. All belts, speed 60 f.p.m.
15	12	Electronic scale, 2-channel, and stainless steel paddle diverter.
16	1	Sized-stalk conveyor, 24-in.×12-ft. To transport sizes 4, 6, and 8 stalks from the first 2-channel scale in line to drop-chute and stalk-spacing conveyor. Elev. 23 in., speed 100 f.p.m.
17	1	Stalk-spacing belt conveyor, 6-in.×8-ft., consisting of 2 sections—first section 3 ft. long; second section 5 ft. long with 3½ ft. inclined and 1½ ft. level. To transport stalks to 3-channel scale. Elev. of belt at drop chute 6 in., at level section 32 in. Speed first section 150 f.p.m., second section 250 f.p.m.
18	1	Electronic scale, 3-channel, and 2 stainless steel paddle diverters to separate sizes 4, 6, and 8 stalks.
19	1	Belt conveyor, 6-in.×9-ft. To transport size 4 stalks from 3-channel scale to packer belt. Elev. 32 in. at scale and inclined to 37 in. at packer belt, speed 250 f.p.m.
20	1	Packer turntable, 7-ft. dia. To pack size 6 celery.
21	1	Belt conveyor, 6-in.×18-ft. To transport size 8 and smaller to trash belt. Metal chute 18 in. wide at head of conveyor connects to conveyor belt at diverter paddle after 3-channel scale. Speed 100 f.p.m.
22	1	Belt conveyor for size 4 celery, 24-in.×10-ft. Workers pack from belt on either side. Elev. 37 in., speed 60 f.p.m.
23	9	Belt conveyor between 2-channel scales, 6-in.×8-ft. Elev. 32 in., speed 415 f.p.m.
24	3	Belt conveyor after last 2-channel scale, 6-in.×13-ft. To transport size No. 1½ stalks to packing belt; metal deflector at end of belt to shear stalks from belt.
25	4	Sized-stalk conveyor, 24-in.×31-ft. To transport sizes 1½, 2, 2½, and 3 to packing stations. Elev. at scale 23 in., elev. at packing stations 37 in. Shear at end of belt removes trash. Under part of belt on return transports trash (stalk petioles) to shear located at trash belt. Speed 60 f.p.m.
26	5	Crate chute, 18-in.×30-ft., 16-gage, with 2-in.-high sides, curve down from overhead makeup area.
27	16	Packer stand, collapsible.
28	4	Live-powered-roller conveyor, 24-in.×16-ft. To transport packed crates away from pack stations. Located under pack belt. Elev. 8 in., speed 100 f.p.m.
29	4	Crate merger.
30	1	Packed-container belt, 24-in.×52-ft., on 8-in. center rollers. Elev. 8 in., speed 100 f.p.m.
31	1	Inclined belt conveyor, 24-in.×3-ft., roughrib. To raise elevation from 8 in. to 28 in. Belt on rollers 4-in. centers. Speed 100 f.p.m.
32	1	Two-way switch, using 12-in. roller conveyor, 6 ft., manually operated.
33	1	Curved (90°) roller conveyor and straight-section 12-in.×3-ft., wheel conveyor with side rails and supports. To transfer cartons to glue sealer.
34	1	Automatic glue sealer for corrugated cartons.
35	1	Automatic closer for wirebound crates.
36	2	Straight-section wheel conveyor, 12-in.×20-ft., with supports.
37	1	Trash belt, 24-in.×56-ft. Located under sized-stalk conveyors in center of sizing line. Elev. 9 in., speed 80 f.p.m.
38	3	Trash belts, consisting of one 36-in.×65-ft. belt located under center stripper belt, elev. 18 in. with inclined section to elevate from 9-in. elev. trash belt, and two 36-in.×40-ft. belts, elev. 18 in., located

Item No.	*Quantity*	*Description*
		under off-angle stripper belts. To transport removed stalk parts to main trash belt. Sides of belt formed by worker platform. Speed 80 f.p.m.
39	1	Trash belt, 36-in.×80-ft., metal slider bed. Elev. 12 in., speed 80 f.p.m.
—	4	Automatic size marker. To stamp celery size on each end of celery crate or carton. Mount at end of each packer belt adjacent to crate merger.
—	4	Wheel conveyor, 12-in.×10-ft. For use in cars during loading.
—	2	Electric fork truck, 3,000-lb.-capacity.

Handling and Packing Operations

As celery stalks are brought to the packinghouse, they are dumped into tanks of water and fed out onto three separate conveyor lines where they are prepared for packing and separated into size categories. The number of workers required for each operation is shown in appendix table 2.

Water dump tanks and feed out

Celery stalks sliding into the water tank from bulk trailers have a tendency to remain entangled as they proceed to the exit end unless the waterflow is sufficient to separate the pile into individual stalks.

Two rows of nozzles should be provided; one at the entry end directed toward the exit end of the tank, and one row approximately 8 feet forward and directed upward (fig. 10). Celery dumped into the tank is pushed toward the second row of nozzles and the pile gradually broken up by the water turbulence at this point (fig. 11). The celery then proceeds to the feed-out conveyor located at the exit end of the tank.

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FIGURE 10.—Empty celery dump tank with water nozzles directed to separate celery into individual stalks.

The capacity of the dump tank should be sufficient to hold approximately four trailer loads of celery; tanks can be constructed of either concrete or metal.

Stripping celery stalks

Celery stalks are conveyed from the tank onto a cross-feed conveyor and then to the stripper belt (fig. 12).

Workers assigned to the stripper belt pick up celery stalks from the jumbled pile of stalks on the conveyor, strip three or four petioles from each stalk, drop the removed petioles onto the trash belt, and place the trimmed stalk on the stalk-removal conveyor. The petioles that are removed are unmarketable either because of external damage or because of shape, size, or color of the petiole.

Initially the stripper belt is 4 feet wide, and then it narrows to 3 feet. From the 3-foot-wide conveyor the stalks pass onto a half-circle rod conveyor that turns the flow of stalks 180° before they pass onto the 2-foot-wide belt. Stalks not removed are returned to the main flow of stalks at the entry end of the 3-foot-wide belt.

The average worker can handle 510.2 stalks per hour. This includes a 10-percent allowance for personal time and fatigue and also time for 7-percent occurrence to trim the celery butt with a knife. At this rate 24 workers should be assigned to each line processing 200 stalks per minute.

Stalk topping and washing

Workers located at the end of the stalk-removal conveyor transfer celery stalks to a mesh belt conveyor leading to the topper saw and washer. The stalks should be horizontally alined with a metal plate attached to the edge of the conveyor. This alinement accurately sets stalks for the top-trimming saw that cuts stalk length to 16 inches.

The topper saw is a circular saw. It should be covered so that workers at the transfer station will not be in danger of cutting their fingers or hands when working.

The transfer workers should guide the flow of stalks onto the feed conveyor without picking

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FIGURE 11.—Celery being separated into individual stalks by turbulent action created by underwater nozzles.

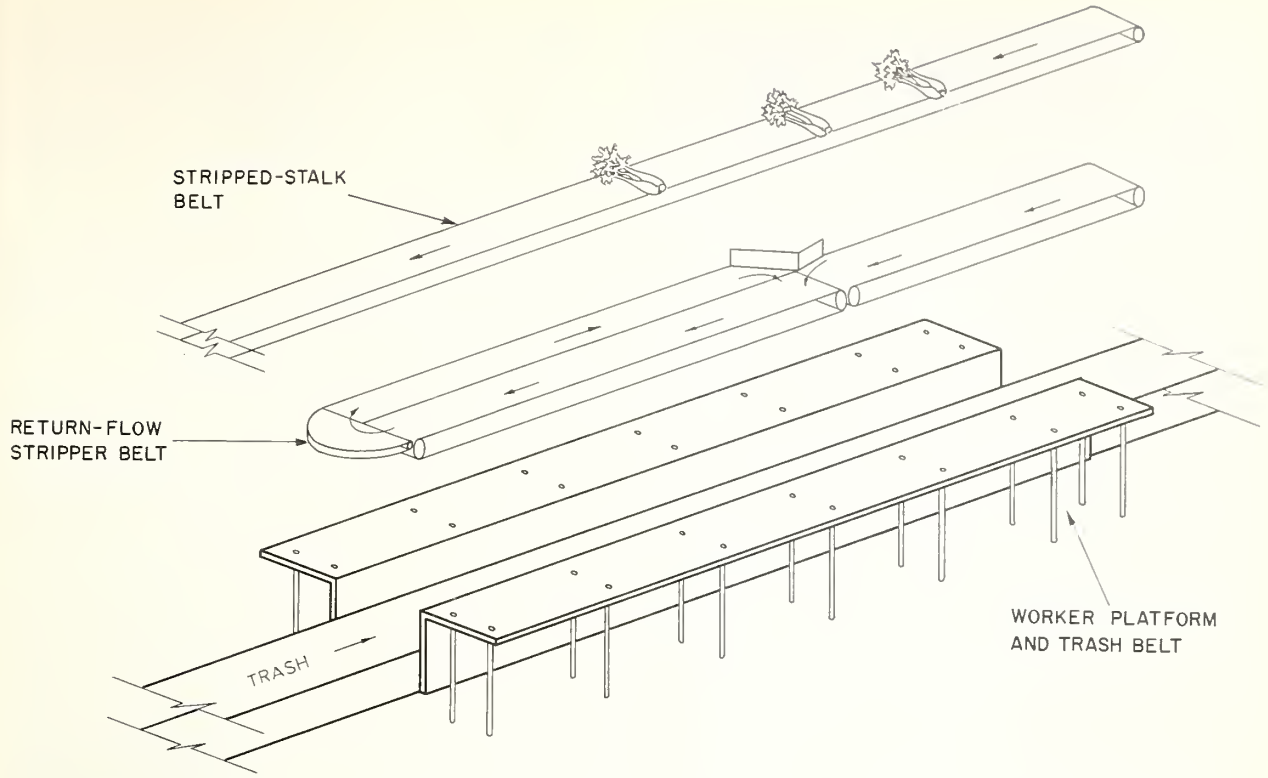

FIGURE 12.—Schematic of stripped-stalk belt, return-flow stripper belt, and worker platform and trash belt.

up each individual stalk. Three workers are needed at this station for each line.

A spray washer is located next in line. Water is sprayed onto the stalks from spray nozzles located within the washer. This spray removes field dirt that remains on the stalks.

Sizing

Figure 8 shows electronic weight-sizing equipment to separate celery stalks into size categories. This equipment has been tested with the feed and stalk-spacing conveyors. It produces a uniform pack with only a small variation in the weight of the packed crates (*6*).

Scales on each main sizing line should separate stalks into only two categories. Stalks weighing in the desired category are diverted from the main flow. Stalks weighing more than the desired weight pass through to the next scale (fig. 13).

The first weigh scale in the celery packing line should remove all stalks weighing less than size 3's. This includes sizes 4, 6, and 8 and smaller. These stalks are conveyed to a three-channel scale where sizes 4 and 6 are separated for packing and size 8 and smaller are conveyed to the trash belt (fig. 14). (In a packinghouse, it probably will not be economical to pack size 8 and smaller.)

The second two-channel scale on the main line diverts size 3's to a packing belt, the third scale separates size 2½'s, and the fourth scale separates size 2's. Size 1½'s (largest size packed in Florida) need not be weighed and can be sent directly to the final packing conveyor.

A problem with this equipment is stalks being spaced too close together as they move across the weighing platform. A minimum of 6 inches is required between stalks. The packinghouse design provides for a photoelectric reject system preceding the first two-channel scale. Stalks that have less than 6 inches space be-

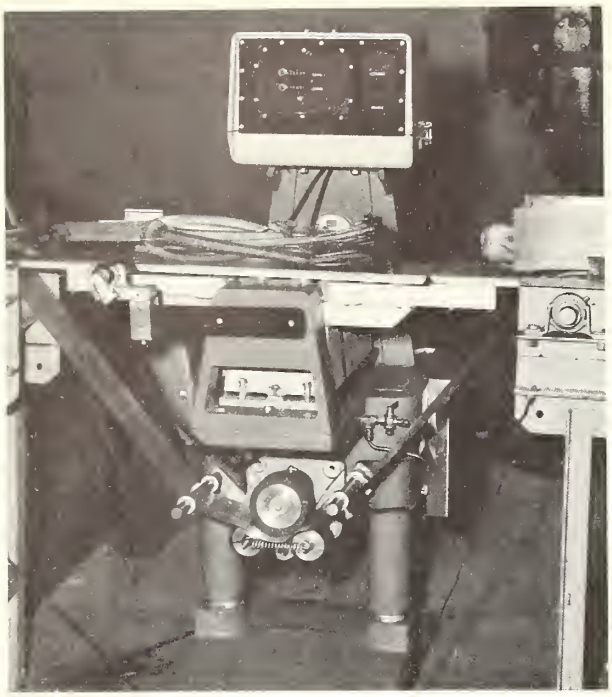

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FIGURE 13.—Electronic scale with celery stalk on the weigh platform. The paddle diverter is just behind the butt of the stalk on the weigh platform.

tween them cause the system to deflect the second stalk from the feed belt. The rejected stalks are then conveyed to the head of the line and placed into the system again.

Packing

The celery packing workplaces are designed to permit workers to reach across the crate to grasp celery stalks on the packer belt.

At each packer workplace, ⅛-inch arresting rods are placed on top of the belt and are fastened to the conveyor frame. The rods stop and hold two or three stalks that will be at right angles to the direction of movement of the belt. When more stalks collect behind a rod, belt pressure shoves the leading stalks across the rod.

Workers at the packing station (fig. 15) reach across the crate to the stalks with both hands and grasp three stalks at a time and place them into the crate. They place alternate layers of celery with the stalk butt facing in opposite directions.

After the crate has been packed, the worker steps to the left and grasps the crate lid with the right hand and rotates it to closed position. With the left hand he pushes on the crate to tip the packing stand off center. The stand lowers, and the packed crate moves onto the live-roller takeaway conveyor located underneath the packing belt (fig. 16).

Packing labor requirements can be further reduced by the use of an automatic size marker at the end of each packing line and by having the liners preglued in the crates.

At the packing station described, a worker can pack 89 crates per hour. This means four workers are needed on a line packing size 2½ that usually produces approximately 350 crates per hour. On the entire packing line packing 1,000 crates per hour, 13 workers are needed.

Figure 9 shows elevations for belt conveyors, empty-crate chute, and packing stand. Note the trash-disposal chute at the end of the packer belt. This chute dumps any petiole that is broken from the stalk onto the underside of the packer belt to be transported to the main trash belt located in the area of the checkweighers.

Closing and stacking crates

Packed crates are transported by the live-roller conveyor to a belt conveyor located at right angles to the end of each packing conveyor. Crates merging at the entry points are controlled by a cam mechanism that acts as a traffic light to control crates arriving from two directions merging at one point. It has two arms at right angles that the crates must push aside when passing the merger device. The first crate pushing the arm aside locks the other arm so the second crate is stopped while the first crate passes the merging device. When the first crate has released the arm, the second crate is released to follow shortly behind.

Packed cartons are separated from crates by a manually operated two-way roller conveyor.

An automatic carton glue sealer and a wire-bound-crate closer have been provided in the packinghouse design. These units close containers at rates of 1,000 to 1,200 per hour.

Workers located at the stacking area separate containers according to stalk size and place them in unit loads of 32 containers each.

Stacks can be made up either with or without pallets.

Two workers are needed at the stacking area to segregate containers and stack them in unit loads for fork truck pickup.

Precooling and loading for shipment

A stack of 32 packed crates of celery, four layers high with eight crates per layer, weighs approximately 2,200 pounds. A palletized stack can be moved with a conventional 3,000-pound capacity fork truck or, if pallets are not used, with a truck equipped with hydraulic clamps (fig. 17).

One fork truck driver is needed to transport celery to the precooler.

Celery can be cooled in either a vacuum cooler or a hydrocooler. There are two styles of hydrocoolers; conventional single-layer flood-type and a unit-load-type. The unit-load style is better adapted to mechanical handling equipment (5).

Crates cooled in the unit-load hydrocooler are set under full-cone water nozzles by the fork truck; one nozzle per stack. Each nozzle should spray approximately 80 gallons per minute of 32° to 35° F. refrigerated water. At this rate, it takes 35.4 minutes to decrease celery temperatures from 75° to 47.2°.

In a unit-load stack, water sprayed onto the top layer flows down through the stack and cools it. Efficiency is not so high as in a conventional hydrocooler because of some reduction

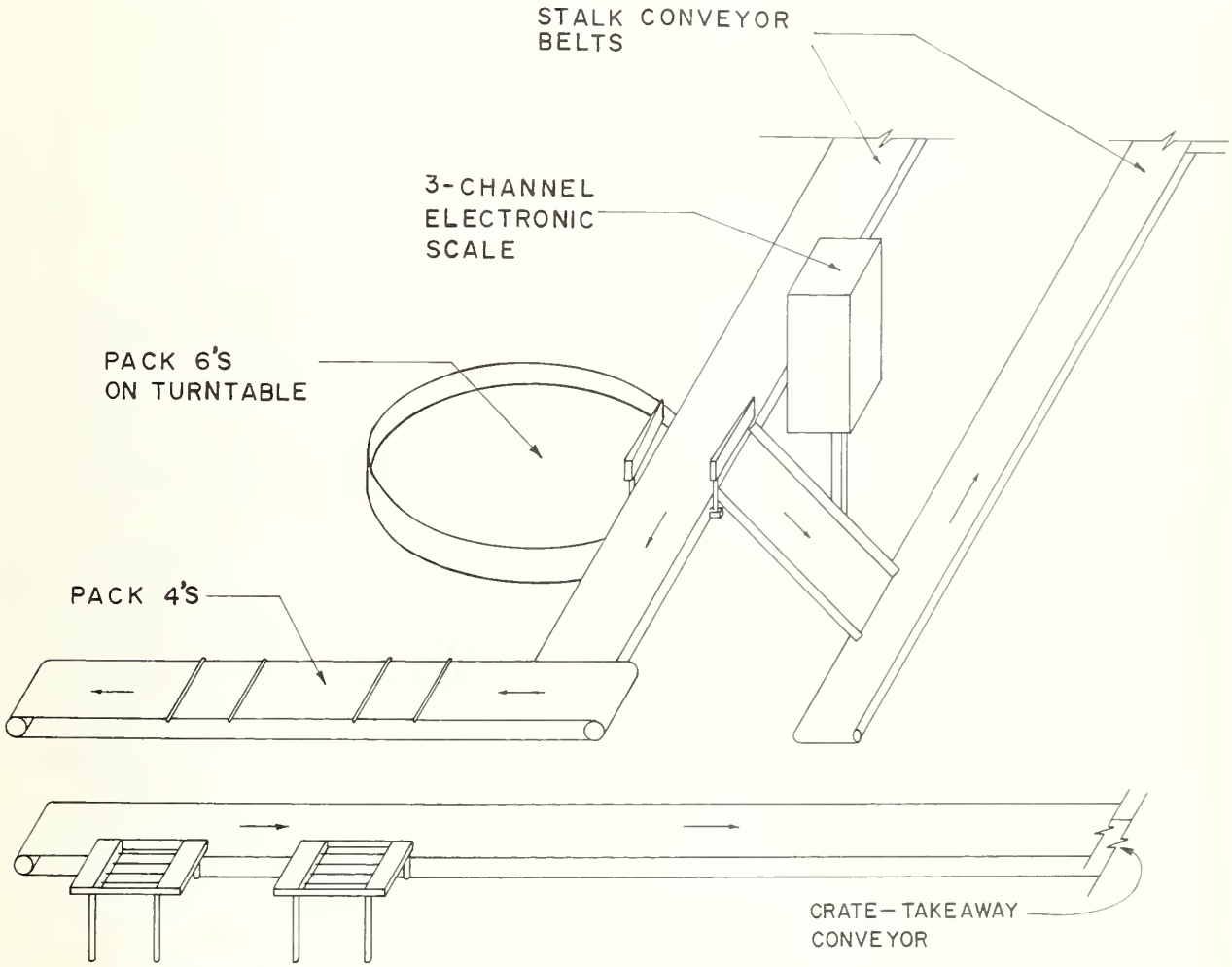


FIGURE 14.—A schematic of the three-channel weigher, packing stations for sizes 4 and 6, and conveyor to trash belt for sizes 8 and smaller.

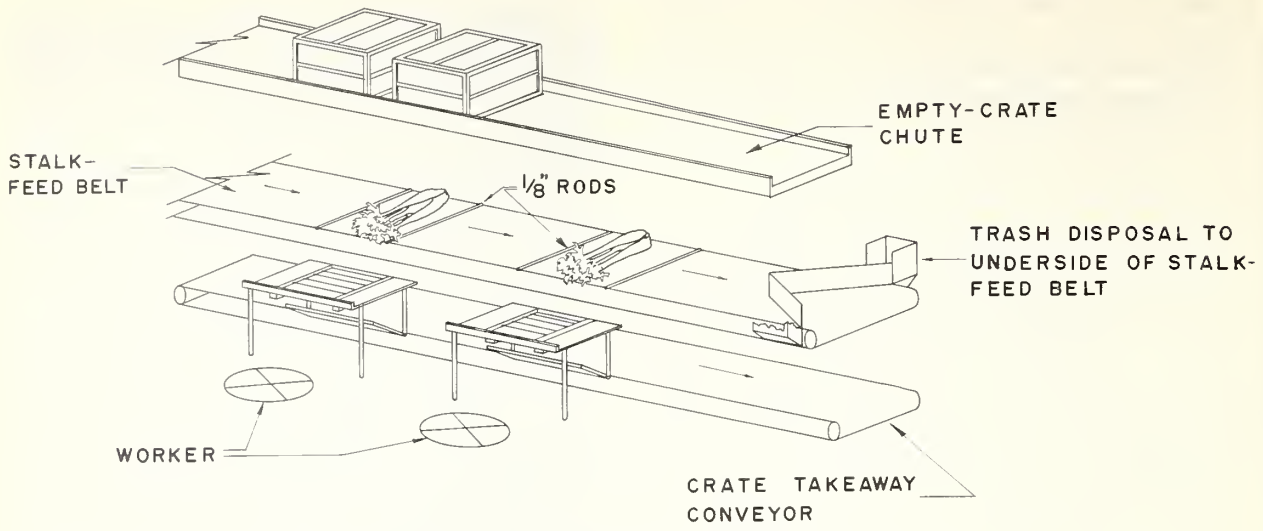


FIGURE 15.—Schematic of packing station showing empty-crate chute, stalk-feed belt, packing stand, and crate-takeaway conveyor.

in waterflow passing through the crates and over the petioles of the stalks. However, labor savings and elimination of several crate rehandling steps more than make up the difference for the additional time (usually 10 minutes) the water should be sprayed onto the stack.

Crates in a unit-load hydrocooler may remain in place after the water is turned off. These crates will remain cool and the celery will retain good quality in the precooling room in temporary cold storage. Water can be periodically turned back onto the stack to either rewet or further cool for better quality retention.

Celery packed in cartons cools better in a vacuum cooler than in the unit-load hydrocooler. Stacks of these containers should be set under a shower outside the vacuum tube and sprayed until wet before placing in the vacuum cooler.

The vacuum cooling process requires approximately 30 minutes to cool celery to 45° F. (*1*). After celery temperatures are reduced sufficiently in the vacuum cooler, the celery should be moved into a refrigerated storage room that has provision for mist spray to maintain high humidity.

One fork truck driver and two loading crews, each consisting of five loaders and a worker to apply brand labels to crates, are needed to load crates and cartons into railroad cars or semitrailer trucks for shipment.

The fork truck driver should pick up the stacks of celery and transport them to the loading dock adjacent to the railroad car or semitrailer truck.

Workers in the loading crew apply glue and brand labels to the ends of the celery crates and set crates onto a wheel conveyor to be conveyed into the railroad car or truck trailer. Two workers at the head of the conveyor stack the containers inside the railroad car or trailer in a loading pattern for shipment. Figure 18 shows a crew of workers loading crates into a railroad car.

Since more crates are shipped by railroad car than by semitrailer truck, the packinghouse design has been laid out with the long dimension of the cooler parallel to the railroad tracks. This reduces fork truck travel distances.

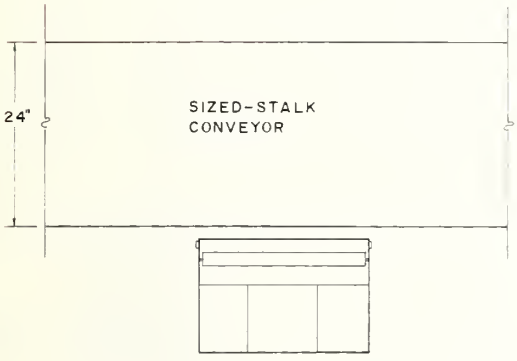
Packing-Line Layout With Monorail Conveyor Sizing Equipment

The packing-line layout designed to use monorail conveyor sizing equipment is shown in detail in figures 19 and 20.

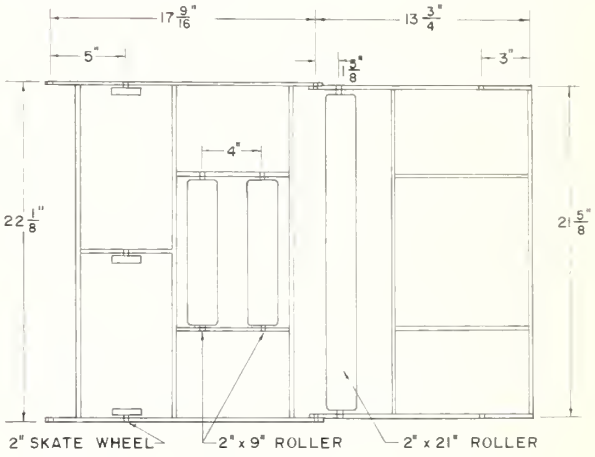
Equipment Requirements

The items of equipment required by this layout follow:

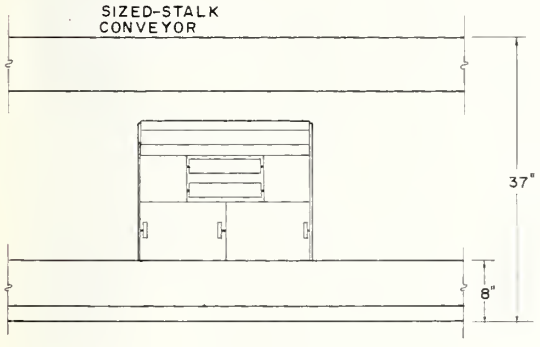
Item No.	*Quantity*	*Description*
1	3	Dump tank (water), 26-×40-×10-ft., with flat bottom, and two 5-hp. pumps to pump water from sump on output end of tank to dump end of tank to create flow of water to move celery to feed-out conveyor.
2	3	Mesh-belt feed-out conveyor, 25-×15-ft., inclined 20° into water tank. Speed 10 f.p.m.
3	3	Cross-feed belt conveyor, consisting of two 36-in.×20-ft. belts, for outside lines, and one 36-in.×3½-ft. and one 36-in.×16½-ft. belt for center line. To feed celery stalks onto stripper conveyors. Elev. 69 in., speed 20 f.p.m.
4	3	Return-flow stripper belt conveyor, consisting of one 48-in.×22-ft., one 36-in. ×25-ft., and one 24-in.×25-ft. belt conveyors and one 2½-ft. R metal rod 180°-turn conveyor. Elev. 56-in., speed 70 f.p.m. Metal deflectors to deflect stalks from 4- to 3-ft. belt and from 2- to 3-ft. belt. Stalks separated on 3- and 2-ft. belt by 5-in.-high metal partition.
5	3	Stalk-removal conveyor, 18-in.×58-ft. To move stripped stalks past topping saw and through spray wash. Elevation at stripper location, 69 in., at exit end, 37 in., speed 70 f.p.m. Conveyor equipped with metal guide at topping saw location to aline stalks.



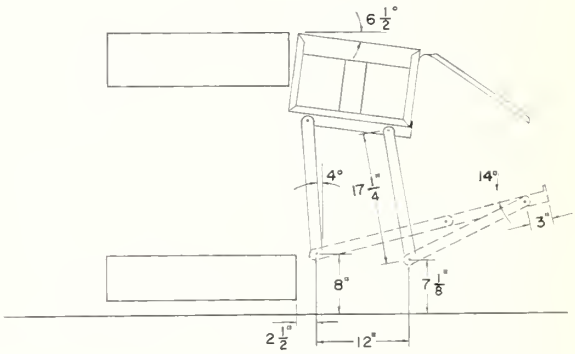
TOP VIEW



PLAN VIEW OF PACKING STAND IN LOWERED POSITION
note use ¼" x 1½" flat stock for framing



FRONT VIEW



SIDE VIEW

FIGURE 16.—Celery packing stand.

Item No.	Quantity	Description
6	6	Platform, wood, 3-×40-ft., elev. 24 in. For workers at stripper belt.
7	3	Circular saw, 15-in.-dia., with smooth or serrated blade. To cut stalks to standard length of 16 in.
8	3	Platform, wood, 3-×3-ft., elev. 26 in. For workers at topping saw.
9	3	Washer, overall dimension 30-in.×5-ft. Water spray from full-cone nozzles onto top, sides, and bottom of celery stalks. Contained in stainless steel housing with water drain at bottom.
10	3	Belt conveyor, 90°-turn, 24-in.-inside-radius, 18-in.-wide. Elev. 37 in., speed 100 f.p.m.
11	3	Belt conveyor to transport stalks from stalk-removal conveyor to monorail conveyor sizers, consisting of one 18-in.×18-ft. for upper stripper line and two 18-in. ×11-ft. for lower lines. Elev. 37 in., speed 100 f.p.m.
12	6	Monorail conveyor sizer, 50-×6-ft. Each with 6 weighing stations for size 1½, 2, 2½, 3, 4, and 6 celery stalks and carrier tripper for size 8 stalks located over disposal system (No. 25) on return side. Carrier cradles, 12-in. center, elevation of cradles, 45 in.
13	6	Sized-stalk conveyor, 24-in.×61-ft. To transport stalks to packing stations. Metal deflector at end of belt shears trash to underpart of belt. Underpart of belt transports trash to shear located at trash belt. Elev. 37 in., speed 60 f.p.m.
14	6	Crate chute, 18-in.×30-ft., 16-gage, with 2-in.-high sides, curve down from overhead makeup area.
15	16	Packer stand, collapsible.
16	6	Live-powered-roller conveyor, 24-in.×16-ft. To transport packed crates away from pack stations. Located under pack belt. Elev. 8 in., speed 100 f.p.m.
17	5	Crate merger.
18	1	Packed-container belt, 24-in.×44-ft., on 8-in. center rollers. Elev. 8 in., speed 100 f.p.m.
19	1	Inclined belt conveyor, 24-in.×3-ft., rough rib. To raise elevation from 8 in. to 28 in. Belt on rollers 4-in. centers. Speed 100 f.p.m.
20	1	Two-way switch, using 12-in. roller conveyor, 6 ft., manually operated.
21	1	Curved (90°) roller conveyor and straight-section 12-in.×3-ft., wheel conveyor with side rails and supports. To transfer cartons to glue sealer.

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FIGURE 17.—Clamp-type truck picking up a stack of celery crates.

Item No.	Quantity	Description
22	1	Automatic glue sealer for corrugated cartons.
23	1	Automatic closer for wirebound crates.
24	2	Straight-section wheel conveyor, 12-in.×20-ft., with supports.
25	1	Disposal system for size 8 stalks, consisting of one 12-in.×30-ft. belt conveyor located beneath carrier trippers on sizers No. 1 through 5, a chute from tripper on sizer No. 5 to trash belt No. 26, and a chute from tripper on sizer No. 6 to underside of sized-stalk belt No. 13. Elevation of belt 30 in., speed 60 f.p.m. Conveyor equipped with chute to lower stalks to trash belt No. 26.
26	1	Trash belt, 24-in.×58-ft., located under sized-stalk conveyors leading to center stripping line. Elev. 18 in., speed 80 f.p.m. Conveyor equipped with chute under each sized-stalk conveyor to guide trash onto belt.
27	3	Trash belt, 36-in.×50-ft., located under stripper lines. Elev. 18 in., speed 80 f.p.m.
28	1	Trash belt, 36-in.×80-ft., located across ends of trash belts No. 27. Elev. 12 in., speed 80 f.p.m.
—	6	Automatic size marker. To stamp celery size on each end of celery crate or carton. Mount at end of each packer belt adjacent to crate merger.
—	4	Wheel conveyor, 12-in.×10-ft. For use in cars during loading.
—	2	Electric fork truck, 3,000-lb.-capacity.

Handling and Packing Operations

Most of the equipment items and handling operations are similar to those of the layout with the electronic sizer. Celery stalks are dumped into the water tanks, fed out onto conveyor lines and stripped of their outer petioles, separated into size categories, and packed.

The tops are trimmed off and the stalks are washed while still on the stalk-removal conveyor, however, instead of being transferred to another conveyor. Three workers (one for each line) are needed to aline stalks for the topping saw.

After the washing operation, the celery stalks are transferred to the monorail conveyor sizer. This sizer is a mechanical beam-type of the same basic design as those used in poultry eviscerating plants to size carcasses; it can be converted to sizing celery stalks without major modification. An overhead monorail conveyor, from which carriers are suspended, moves the stalks past several weighing stations (fig. 21).

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FIGURE 18.—Crew of workers loading crates into railroad car.

At the first weighing station, the largest celery stalks (size 1½) fall onto a conveyor belt leading to the packing area. Smaller stalks proceed along the conveyor to other weighing stations where they are separated into size categories.

A carrier tripper is located on the return side of the conveyor. At this location, any remaining stalks (size 8 and smaller) are dumped into chutes leading to the trash belt.

Twelve workers (2 for each sizer) are needed to transfer celery stalks from the stalk-removal conveyor to the sizing equipment.

Celery stalks are packed, precooled, and shipped as in layout with electronic sizer.

The number of workers required for each operation are given in appendix table 3.

Structural Design

When an efficient packing line has been developed, a building can be built to fit the operating pattern. One building layout that incorporates a unit-load hydrocooler is shown in figure 7. The layout also provides facilities for both truck and rail loadout, offices, space for

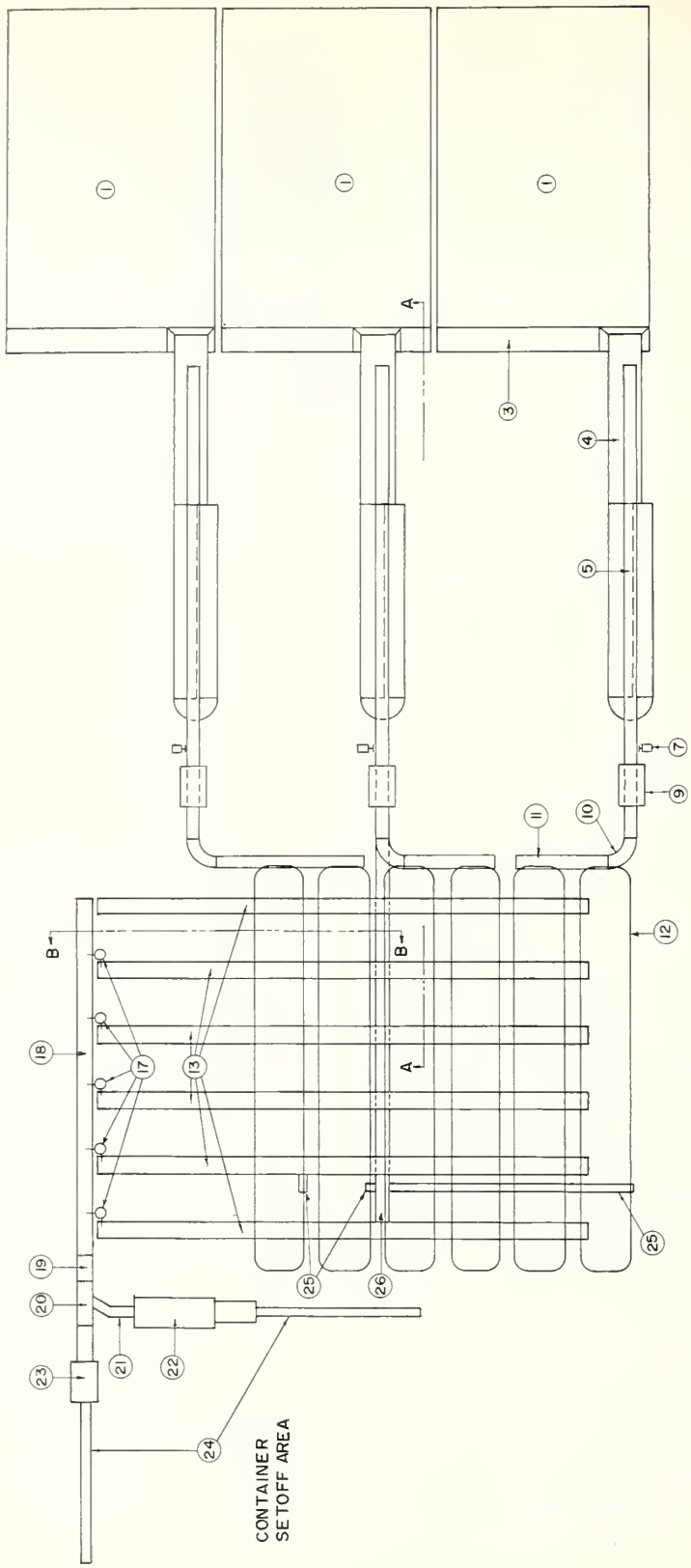

FIGURE 19.—Packing-line layout for monorail conveyor sizing equipment. (See figure 20 for elevations of sections and p. 18 for identification of numbered parts.)

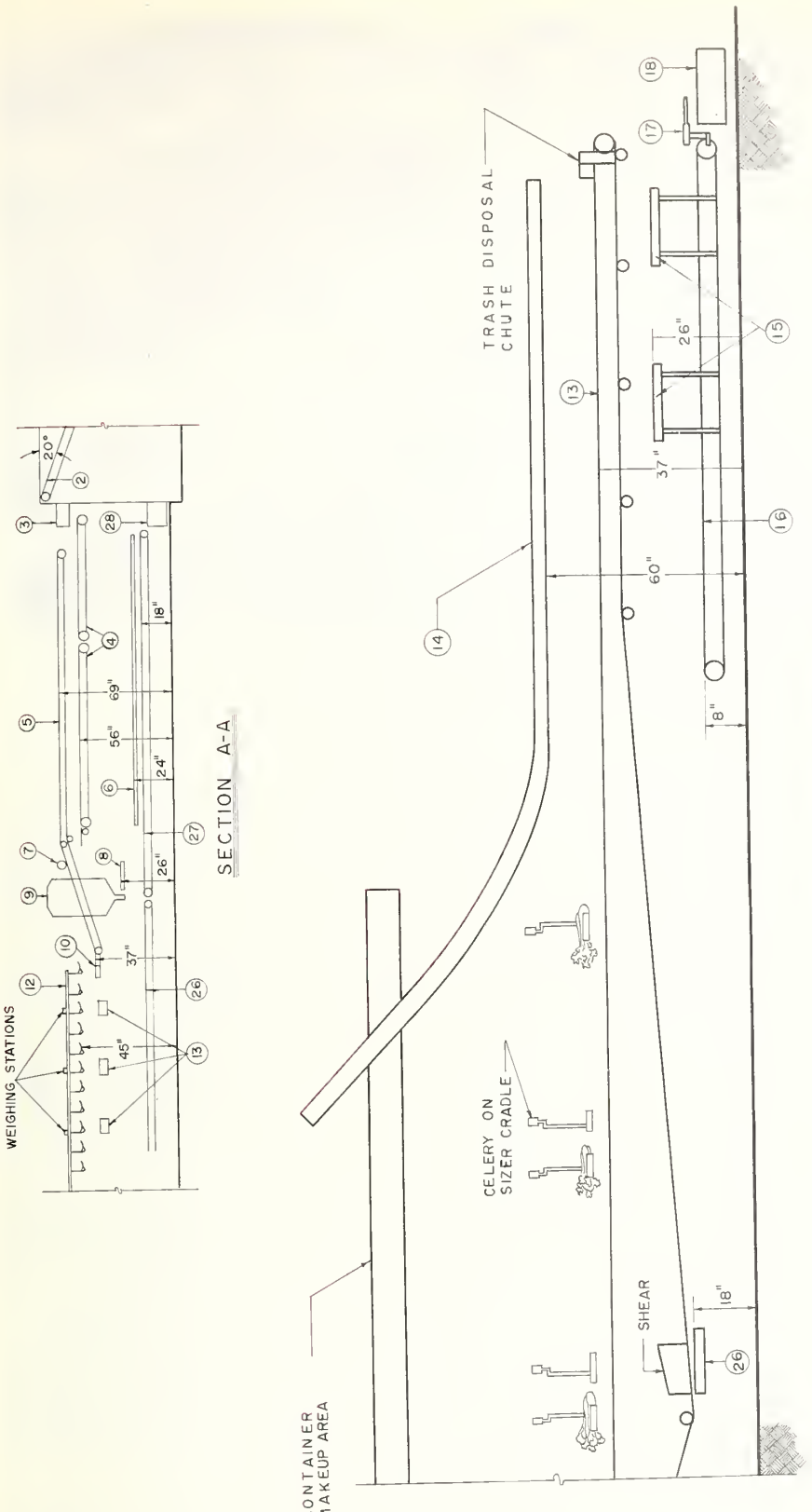

FIGURE 20.—Elevations of sections of packing-line layout shown in figure 19: A-A, Stripper belt, washers, and monorail conveyor sizing equipment; B-B, packing belt and monorail conveyor sizers. (See p. 18 for identification of numbered parts.)

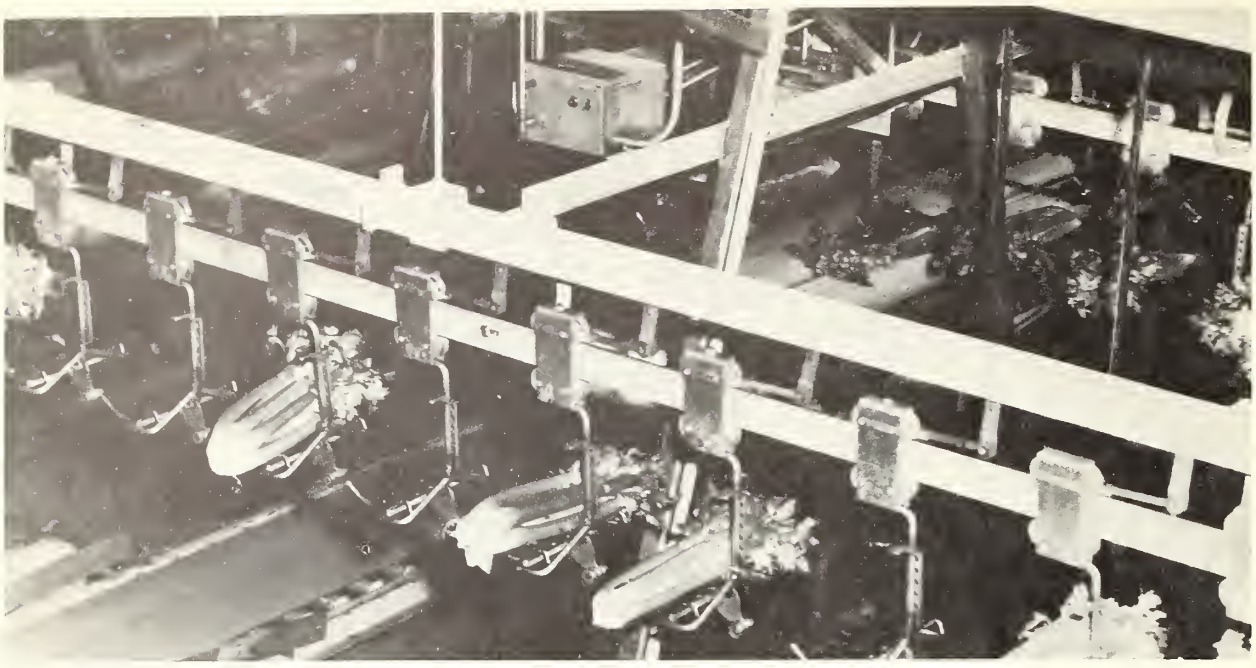

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FIGURE 21.—Monorail conveyor sizer with celery stalks in position on carriers.

dry storage and box makeup, and a room for refrigeration equipment that chills the hydrocooler water.

The site plan should include ample parking for trucks and for employee cars.

There are several possible construction materials for celery packinghouses. Some plants have been constructed with steel frames and roofs; others with concrete masonry walls and pre-stressed concrete roofs. Most plant floors are constructed of reinforced concrete designed to support fork trucks.

Floor drains should be provided in the packing area and in the hydrocooling room. Because of the large volume of water used for hydrocooling, special consideration must be given to the design of the floor and drains in the hydrocooler. The floor should have a slope of not less than 2 inches in 10 feet to facilitate water runoff to the drains. The sump for the water supply should be designed so there is always a drop from the floor drain channels to its water surface; otherwise, the drains cannot handle the flow for which they were designed and flooding will occur.

The hydrocooler should be insulated to reduce refrigeration load. Frequently, insulation board is used for the interior finish. Since this board is vulnerable to mechanical damage from fork trucks, a concrete curb about 1 foot high around the perimeter of the room is desirable.

Since fork trucks are used to move crates of celery into and out of the hydrocooler, the large doors must be open much of the time. Air doors will substantially reduce the flow of warm air into the room. If more than one door is open on windy days, a return-flow door such as is described in "Air Door for Cold Storage Houses" is the most effective (*7*).

The building cost depends on material selection. Choice of material for quality or aesthetic purposes may substantially increase the cost. Some other factors may not be directly controllable, such as sites that may require excavation and back fill or may require deep footings. Also, there may be local variations in availability and cost of materials and availability of labor skilled in a particular construction method.

Use of fire-resistant materials add little, if

any, to the cost and will reduce insurance premiums. Safety features such as sprinkler systems are less expensive if included during initial construction.

If an architect or engineer has been selected to work with the owner in developing the plans, he can assist in obtaining cost estimates that permit alternative choices of materials, quality, and other factors that influence the cost. He can also prepare detailed plans and specifications that allow competitive bidding among contractors and provide a precise understanding between contractor and owner. Plans and specifications help hold costly additions and plan changes during construction to a minimum.

COMPARATIVE COSTS FOR PACKING SYSTEMS

Individual celery crates are manually handled several times in the mule train packing system; this not only causes a need for numerous workers but also considerable crate breakage. When compared with the mule train harvesting and packing system, the central packinghouse offers several advantages. Labor costs are reduced because of the mechanical handling systems used; crate breakage caused by the large amount of rehandling in the mule train system is reduced; and costs can be controlled more closely by management in the centralized system.

Labor Costs

Changes that have occurred in Florida during the last 5 years (1964–69) have reduced labor availability and have increased labor costs. A 1964 feasibility study of the central packing-precooling plant system estimated labor saving of 10.9 cents per crate over the mule train harvesting and packing system. A 1967 comparison indicated labor costs per crate for the mechanical harvest and central packing system were 20.8 cents with electronic weight sizers and 21.6 cents with monorail conveyor sizers. Labor cost for the mule train system was 39.5 cents per crate, which meant a saving of 18.7 cents per crate with electronic sizers and 17.9 cents with monorail conveyor sizers.

The number of workers required to handle 1,000 crates of celery per hour is reduced 43 percent in the central packinghouse system with electronic sizers and 41 percent with monorail conveyor sizers. Labor requirements, wage rates, and hourly costs for each system of harvesting, handling, and packing are shown in appendix tables 1, 2, and 3.

Equipment and Facility Costs

Equipment costs (1967) for each of the three systems of harvesting and packing celery, along with estimated service life, number of units of equipment needed, and annual ownership and operating costs, are shown in appendix tables 4, 5, and 6.

A mule train harvesting and packing system capable of packing an hourly volume of 1,000 crates required an initial investment of approximately $246,875 for equipment.

The mule train harvesting and packing system requires a temporary storage floor, a precooling plant, and a loading dock. Estimated facility cost (1967) was based on $5 per square foot for the precooling plant and storage area and $3 per square foot for the loading dock. Dimensions for the floor storage area for wire-bound crates were 80 by 200 feet, those for the precooler were 30 by 80 feet, and those for the loading dock were 6 by 400 feet. Basic cost of these facilities was $99,200.

A four-bay (each bay five crates wide) single-layer-crate hydrocooler with capacity of 1,000 crates per hour cost approximately $145,000. This included cost of refrigeration compressors and condensers, piping, water nozzles, and water sump tank. It did not include cost of slat conveyors and drive, which has been itemized separately in equipment cost.

Total capital investment for the mule train packing and conventional hydrocooling system was $491,075 (1967).

Initial equipment cost to handle 1,000 crates per hour for the mechanical harvesting system and central packinghouse using electronic sizers was $350,813. Equipment cost for the system using monorail conveyor sizers was $359,893.

Both of the central packinghouse systems require a packing plant with approximate dimensions of 170 x 180 feet. This building must include space for the packing line, loading docks, unit-load precooler, and refrigeration compressor room. At $8.50 per square foot, the basic cost for the packing plant was $260,100 (1967).

A unit-load hydrocooler with 1,000-crate-per-hour capacity cost approximately $110,000. This included refrigeration compressors and condensers, piping, water nozzles, and water sump tank.

Total capital investment (1967) for the central packing system was $720,913 with electronic sizers and $729,993 with monorail conveyor sizers.

Total Labor and Equipment Costs

Based on an annual volume of 1,000,000 crates, labor and equipment costs per crate were 48.3 cents with the mule train system, 30.1 cents for the central system with electronic sizers, and 31.1 cents with monorail sizers.

When compared with the mule train harvesting and packing system, saving in annual labor and equipment cost (as shown below) for the central system was $182,054 with electronic sizers and $172,820 with monorail conveyor sizers. This means a savings per crate of 18.2 cents and 17.2 cents, respectively. This saving will pay for the initial equipment and facility costs for either of the central packinghouse systems in approximately 4 years.

Costs for packing 1,000,000 crates of celery

Cost item	Mule train	Mechanical harvester and central packinghouse with—	
		Electronic sizer	Monorail sizer
Equipment	$88,381.76	$93,828.27	$94,961.95
Labor	395,050.00	207,550.00	215,650.00
Total	$483,431.76	$301,378.27	$310,611.95

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APPENDIX

TABLE 1.—*Estimated number of workers required and labor cost to handle 1,000 crates of celery per hour with mule train system, 1967*

Job title	Workers required per 4 mule trains	Hourly wage rate [1]	Hourly cost per 4 mule trains
	Number	*Dollars*	*Dollars*
Field:			
Machine supervisor	4	3.00	12.00
Machine driver	4	1.25	5.00
Celery cutters	64	1.75	112.00
Top stalks	8	1.25	10.00
Packers	72	1.75	126.00
Crate setoff	24	1.50	36.00
Close crates	8	1.50	12.00
Load field truck	4	1.50	6.00
Make crates	4	2.30	7.20
Total mule trains	192	----------	328.20
Truck drivers	10	1.60	16.00
Precooling plant:			
Unload supervisor	1	1.90	1.90
Unload trucks (2 crews)	14	1.35	18.90
Set crates on conveyor to precooler	3	1.35	4.05
Precooler supervisor	1	2.60	2.60
Check crates	1	2.00	2.00
Handle crates to precooler	2	1.60	3.20
Label crates	2	1.35	2.70
Loading supervisors	2	1.75	3.50
Load crates in cars (2 crews)	8	1.50	12.00
Total precooler	34	----------	50.85
Total per system	236	----------	395.05

[1] Most celery workers in Florida are paid on a piece-rate basis. The hourly wage rate is the average that a qualified worker could be expected to earn.

TABLE 2.—*Estimated number of workers required and labor cost to handle 1,000 crates of celery per hour with mechanical harvesting, electronic weigh sizing, and in-plant packing system, 1967*

Job title	Workers required	Hourly wage rate[1]	Hourly cost
	Number	*Dollars*	*Dollars*
Field:			
Harvester supervisor	1	3.00	3.00
Harvester drivers	2	1.50	3.00
Tractor-trailer drivers	6	1.50	9.00
Total field	9		15.00
Packing-precooling plant:			
Unloading and stalk-stripping supervisor	1	3.00	3.00
Feed-packing line	3	1.50	4.50
Trim and strip stalks	72	1.50	108.00
Truck driver and helper to dispose of trash	2	1.50	3.00
Transfer stalks to sizing line	9	1.35	12.15
Packers	13	1.75	22.75
Packing supervisor	1	3.00	3.00
Make crates	4	1.75	7.00
Close crates	1	1.50	1.50
Stack crates	2	1.35	2.70
Fork truck driver—load precooler	1	1.50	1.50
Precooler operator	1	2.50	2.50
Label crates	2	1.35	2.70
Fork truck driver—load railroad cars	1	1.50	1.50
Loading supervisor	1	1.75	1.75
Loading crews	10	1.50	15.00
Total precooler	124		192.55
Total per system	133		207.55

[1] Most celery workers in Florida are paid on a piece-rate basis. The hourly wage rate is the average that a qualified worker could be expected to earn.

TABLE 3.—*Estimated number of workers required and labor cost to handle 1,000 crates of celery per hour with mechanical harvesting, monorail conveyor weigh sizing, and in-plant packing system, 1967*

Job title	Workers required	Hourly wage rate [1]	Hourly cost
	Number	*Dollars*	*Dollars*
Field:			
Harvester supervisor	1	3.00	3.00
Harvester drivers	2	1.50	3.00
Tractor-trailer drivers	6	1.50	9.00
Total field	9	----------	15.00
Packing-precooling plant:			
Unloading and stalk-stripping supervisor	1	3.00	3.00
Feed-stripping line	3	1.50	4.50
Trim and strip stalks	72	1.50	108.00
Truck driver and helper to dispose of trash	2	1.50	3.00
Aline stalks for top saw	3	1.35	4.05
Transfer stalks to sizer	12	1.35	16.20
Packers	13	1.75	22.75
Packing supervisor	1	3.00	3.00
Make crates	4	1.75	7.00
Close crates	1	1.50	1.50
Stack crates	2	1.35	2.70
Fork truck driver—load precooler	1	1.50	1.50
Precooler operator	1	2.50	2.50
Label crates	2	1.35	2.70
Fork truck driver—load cars	1	1.50	1.50
Loading supervisor	1	1.75	1.75
Loading crews	10	1.50	15.00
Total packing-precooling	130	----------	200.65
Total per system	139	----------	215.65

[1] Most celery workers in Florida are paid on a piece-rate basis. The hourly wage rate is the average that a qualified worker could be expected to earn.

TABLE 4.—*Annual equipment cost to pack celery with the mule train system, 1967*

Equipment item	Initial cost per unit	Expected life	Annual ownership costs				Annual operating costs [2]			Annual cost per unit	Number units needed	Total annual cost
			Depreciation	Interest at 6 percent[1]	Insurance and taxes at 4 percent[1]	Total	Power [3]	Maintenance [4]	Total			
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*
Mule train harvester	25,000	10	2,500.00	825.00	1,000.00	4,325.00	600.00	4,000.00	4,600.00	8,925.00	4	35,700.00
Field trucks	8,000	4	2,000.00	300.00	320.00	2,620.00	700.00	560.00	1,260.00	3,880.00	10	38,800.00
Wheel unloading conveyor, 20-ft	85	5	17.00	3.06	3.40	23.46		.50	.50	23.96	5	119.80
Chain conveyor, 200-ft	7,000	10	700.00	231.00	280.00	1,211.00	60.00	28.00	88.00	1,299.00	5	6,495.00
Belt conveyor, 30-ft	1,250	8	156.25	42.19	50.00	248.44	30.00	5.00	35.00	283.44	4	1,133.76
Precooler slat conveyor	3,000	6	500.00	105.00	120.00	725.00	60.00	18.00	78.00	803.00	4	3,212.00
Chain conveyor, 400-ft	14,000	10	1,400.00	462.00	560.00	2,422.00	300.00	70.00	370.00	2,792.00	1	2,792.00
Wheel loading conveyor, 10-ft	45	5	9.00	1.62	1.80	12.42		.50	.50	12.92	10	129.20
Total cost												88,381.76

[1] Interest based on average investment over the life of the equipment; insurance and taxes based on initial investment.

[2] Based on 1,000 hours of annual use except field trucks 700 hours annual use.

[3] Based on 3 cents per kilowatt hour for electricity.

[4] Estimated annual costs.

TABLE 5.—*Annual equipment cost to pack celery with the mechanical harvester and central packinghouse system using electronic weigh sizers, 1967*

Item No.	Equipment item	Initial cost per unit	Expected life	Annual ownership costs				Annual operating costs [2]			Annual cost per unit	Number units needed	Total annual cost
				Depreciation	Interest at 6 percent [1]	Insurance and taxes at 4 percent [1]	Total	Power [3]	Maintenance [4]	Total			
		Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*
—	Mechanical harvester	12,000	10	1,200.00	396.00	480.00	2,076.00	300.00	600.00	900.00	2,976.00	3	8,928.00
—	Bulk-celery trailers	4,500	6	750.00	157.50	180.00	1,087.50		200.00	200.00	1,287.50	18	23,175.00
—	Tractor	9,000	4	2,250.00	337.50	360.00	2,947.50	400.00	500.00	900.00	3,847.50	6	23,085.00
1	Water dump tanks	5,310	10	531.00	175.23	212.40	918.63		100.00	100.00	1,018.63	3	3,055.89
2	Mesh-belt feed-out conveyor	5,586	10	558.60	184.34	223.44	966.38	15.00	150.00	165.00	1,131.38	3	3,394.14
3	Cross-feed conveyor, 36-in. ×10-ft.	760	10	76.00	25.08	30.40	131.48	15.00	20.00	35.00	166.48	6	998.88
4	Return-flow conveyor	4,950	10	495.00	163.35	198.00	856.35	45.00	165.00	210.00	1,066.35	3	3,199.05
5	Belt conveyor, 18-in.×50-ft	1,325	10	132.50	43.73	53.00	229.23	15.00	60.00	75.00	304.23	2	608.46
5	Belt conveyor, 18-in.×48-ft	1,310	10	131.00	43.23	52.40	226.63	15.00	60.00	75.00	301.63	1	301.63
6	Platform for stripper workers	340	5	68.00	12.24	13.60	93.84		10.00	10.00	103.84	6	623.04
7	Mesh-belt feed conveyor, 20-in.×17-ft	1,380	10	138.00	45.54	55.20	238.74	10.00	30.00	40.00	278.74	3	836.22
8	Circular saw	95	10	9.50	3.14	3.80	16.44	7.50	5.00	12.50	28.94	3	86.82
9	Platform for stalk-spacing workers	320	5	64.00	11.52	12.80	88.32		10.00	10.00	98.32	1	98.32
10	Washer	1,350	10	135.00	44.55	54.00	233.55		15.00	15.00	248.55	1	248.55
11	Celery-drop chute	25	10	2.50	.83	1.00	4.33		1.00	1.00	5.33	4	21.32
12	Stalk spacer, 6-in.× 9-ft.	570	10	57.00	18.81	22.80	98.61	7.50	8.00	15.50	114.11	3	342.33
13	Electric eye and paddle reject system	650	10	65.00	21.45	26.00	112.45	5.00	25.00	30.00	142.45	3	427.35
14	Belt conveyors, 18-in.×15-ft., 12-in.×29-ft., and 18-in. ×18-ft.	2,420	10	242.00	79.86	96.80	418.66	22.50	80.00	102.50	521.16	1	521.16
15	Two-channel weigher	2,750	10	275.00	90.75	110.00	475.75	10.00	50.00	60.00	535.75	12	6,429.00
16	Belt conveyor, 24-in.×12-ft	720	10	72.00	23.76	28.80	124.56	7.50	20.00	27.50	152.06	1	152.06
17	Stalk spacer, 1-in.×8-ft	520	10	52.00	17.16	20.80	89.96	7.50	8.00	15.50	105.46	1	105.46
18	Three-channel weigher	3,550	10	355.00	117.15	142.00	614.15	10.00	50.00	60.00	674.15	1	674.15
19	Belt conveyor, 6-in.×9-ft	520	10	52.00	17.16	20.80	89.96	7.50	10.00	17.50	107.46	1	107.46
20	Packer turntable, 7-ft. dia	500	5	100.00	18.00	20.00	138.00	7.50	10.00	17.50	155.50	1	155.50
21	Disposal conveyor for size 8 stalks, 6-in.×18-ft	640	10	64.00	21.12	25.60	110.72	7.50	25.00	32.50	143.22	1	143.22
22	Packer belt, 24-in.×10-ft	610	10	61.00	20.13	24.40	105.53	7.50	25.00	32.50	138.03	1	138.03
23	Belt conveyor, 6-in.×8-ft	460	10	46.00	15.18	18.40	79.58	7.50	10.00	17.50	97.08	9	873.72

See footnotes at end of table.

TABLE 5.—*Annual equipment cost to pack celery with the mechanical harvester and central packinghouse system using electronic weigh sizers, 1967—Continued*

Item No.	Equipment item	Initial cost per unit	Expected life	Annual ownership costs				Annual operating costs [2]			Annual cost per unit	Number units needed	Total annual cost
				Depreciation	Interest at 6 percent [1]	Insurance and taxes at 4 percent [1]	Total	Power [3]	Maintenance [4]	Total			
		Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*
24	Belt conveyor, 6-in.×13-ft.	580	10	58.00	19.14	23.20	100.34	7.50	10.00	17.50	117.84	3	353.52
25	Sized-stalk conveyor, 24-in. ×31-ft.	1,440	10	144.00	47.52	57.60	249.12	10.00	40.00	50.00	299.12	4	1,196.48
26	Crate chute	180	12	15.00	5.85	7.20	28.05		1.00	1.00	29.05	5	145.25
27	Packer stand	140	12	11.67	4.55	5.60	21.82		2.00	2.00	23.82	16	381.12
28	Live-powered-roller conveyor, 24-in.×16-ft.	1,800	10	180.00	59.40	72.00	311.40	15.00	40.00	55.00	366.40	4	1,465.60
29	Crate merger	175	10	17.50	5.78	7.00	30.28		5.00	5.00	35.28	4	141.12
30	Packed-container conveyor, 24-in.×52-ft.	1,800	10	180.00	59.40	72.00	311.40	30.00	75.00	105.00	416.40	1	416.40
31	Inclined belt conveyor, 24-in. ×3-ft.	570	10	57.00	18.81	22.80	98.61	15.00	20.00	35.00	133.61	1	133.61
32	Two-way roller conveyor switch, 6-ft.	290	8	36.25	9.79	11.60	57.64		1.00	1.00	58.64	1	58.64
33	Curved (90°) and 3-ft. straight-section wheel conveyor	160	8	20.00	5.40	6.40	31.80		1.00	1.00	32.80	1	32.80
34	Carton sealer and compressor	8,676	10	867.60	286.31	347.04	1,500.95	19.00	300.00	319.00	1,819.95	1	1,819.95
35	Automatic closer for wirebound crates	8,984	10	898.40	296.47	359.36	1,554.23	11.00	200.00	211.00	1,765.23	1	1,765.23
36	Wheel conveyor, 12-in.×20-ft.	90	8	11.25	3.04	3.60	17.89		1.00	1.00	18.89	2	37.78
37	Trash belt, 24-in.×56-ft.	1,500	10	150.00	49.50	60.00	259.50	7.50	50.00	57.50	317.00	1	317.00
38	Trash belt, 36-in.×65-ft.	2,450	10	245.00	80.85	98.00	423.85	30.00	75.00	105.00	528.85	1	528.85
38	Trash belt, 36-in.×40-ft.	1,345	10	134.50	44.39	53.80	232.69	30.00	40.00	70.00	302.69	2	605.38
39	Trash belt, 36-in.×80-ft.	3,020	10	302.00	99.64	120.80	522.44	60.00	80.00	140.00	662.44	1	662.44
—	Fork truck, 3,000-lb	7,500	7	1,071.43	257.14	300.00	1,628.57	270.00	450.00	720.00	2,348.57	2	4,697.14
—	Wheel conveyor, 12-in.×10-ft.	45	5	9.00	1.62	1.80	12.42		1.00	1.00	13.42	4	53.68
—	Automatic size marker	300	8	37.50	10.13	12.00	59.63		12.00	12.00	71.63	4	286.52
	Total cost												93,828.27

[1] Interest based on average investment over the life of the equipment; insurance and taxes based on initial investment.

[2] Based on 1,000 hours annual use.

[3] Based on 3 cents per kilowatt hour for electricity.

[4] Estimated annual costs.

TABLE 6.—*Annual equipment cost to pack celery with the mechanical harvester and central packinghouse using monorail conveyor sizers, 1967*

Item No.	Equipment item	Initial cost per unit	Expected life	Annual ownership costs				Annual operating costs [2]			Annual cost per unit	Number units needed	Total annual cost
				Depreciation	Interest at 6 percent [1]	Insurance and taxes at 4 percent [1]	Total	Power [3]	Maintenance [4]	Total			
		Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*
—	Mechanical harvester	12,000	10	1,200.00	396.00	480.00	2,076.00	300.00	600.00	900.00	2,976.00	3	8,928.00
—	Bulk-celery trailer	4,500	6	750.00	157.50	180.00	1,087.50		200.00	200.00	1,287.50	18	23,175.00
—	Tractor	9,000	4	2,250.00	337.50	360.00	2,947.50	400.00	500.00	900.00	3,847.50	6	23,085.00
1	Water dump tank	5,310	10	531.00	175.23	212.40	918.63		100.00	100.00	1,018.63	3	3,055.89
2	Feed-out conveyor	5,586	10	558.60	184.34	223.44	966.38	15.00	150.00	165.00	1,131.38	3	3,394.14
3	Cross-feed conveyor (outside lines), 36-in.×20-ft	1,450	10	145.00	47.85	58.00	250.85	15.00	25.00	40.00	290.85	2	581.70
3	Cross-feed conveyors (middle line), 36-in.×16½-ft. and 36-in.×3½-ft	1,550	10	155.00	51.15	62.00	268.15	15.00	35.00	50.00	318.15	1	318.15
4	Return-flow conveyor	4,950	10	495.00	163.35	198.00	856.35	45.00	165.00	210.00	1,066.35	3	3,199.05
5	Stalk-removal conveyor, 18-in. ×58-ft	1,385	10	138.50	45.71	55.40	239.61	15.00	60.00	75.00	314.61	3	943.83
6	Platform for stripper workers	340	5	68.00	12.24	13.60	93.84		10.00	10.00	103.84	6	623.04
7	Circular saw	95	10	9.50	3.14	3.80	16.44	7.50	5.00	12.50	28.94	3	86.82
8	Platform for saw workers	50	5	10.00	1.80	2.00	13.80		5.00	5.00	18.80	3	56.40
9	Washer	450	10	45.00	14.85	18.00	77.85		5.00	5.00	82.85	3	248.55
10	Conveyor 90° turn	550	10	55.00	18.15	22.00	95.15	7.50	8.00	15.50	110.65	3	331.95
11	Conveyor (upper line), 18-in. ×18-ft	780	10	78.00	25.74	31.20	134.94	15.00	20.00	35.00	169.94	1	169.94
11	Conveyor (lower lines), 18-in. ×11-ft	650	10	65.00	21.43	26.00	112.45	15.00	20.00	35.00	147.45	2	294.90
12	Monorail conveyor sizer	8,500	10	850.00	280.50	340.00	1,470.50	15.00	100.00	115.00	1,585.50	6	9,513.00
13	Sized-stalk conveyor, 24-in. ×61-ft	1,900	10	190.00	62.70	70.00	322.70	15.00	60.00	75.00	397.70	6	2,386.20
14	Crate chute	180	12	15.00	5.85	7.20	28.05		1.00	1.00	29.05	6	174.30
15	Packer stand	140	12	11.67	4.55	5.60	21.82		2.00	2.00	23.82	16	381.12
16	Live-powered-roller crate conveyor, 24-in.×16-ft	1,800	10	180.00	59.40	72.00	311.40	15.00	40.00	55.00	366.40	6	2,198.40
17	Crate merger	175	10	17.50	5.78	7.00	30.28		5.00	5.00	35.28	5	176.40
18	Packed-container conveyor, 24-in.×44-ft	1,650	10	165.00	54.45	66.00	285.45	30.00	65.00	95.00	380.45	1	380.45

See footnotes at end of table.

TABLE 6.—*Annual equipment cost to pack celery with the mechanical harvester and central packinghouse using monorail conveyor sizers, 1967—Continued*

Item No.	Equipment item	Initial cost per unit	Expected life	Annual ownership costs				Annual operating costs [2]			Annual cost per unit	Number units needed	Total annual cost
				Depreciation	Interest at 6 percent [1]	Insurance and taxes at 4 percent [1]	Total	Power [3]	Maintenance [4]	Total			
		Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*
19	Inclined belt conveyor, 24-in. ×3-ft	570	10	57.00	18.81	22.80	98.61	15.00	20.00	35.00	133.61	1	133.61
20	Two-way roller conveyor switch	290	8	36.25	9.79	11.60	57.64		1.00	1.00	58.64	1	58.64
21	Curved (90°) and 3-ft. straight-section wheel conveyor	160	8	20.00	5.40	6.40	31.80		1.00	1.00	32.80	1	32.80
22	Carton sealer and compressor	8,676	10	867.60	286.31	347.04	1,500.95	19.00	300.00	319.00	1,819.95	1	1,819.95
23	Closer for wirebound crates	8,984	10	898.40	296.47	359.36	1,554.23	11.00	200.00	211.00	1,765.23	1	1,765.23
24	Wheel conveyor, 12-in.×20-ft	90	8	11.25	3.04	3.60	17.89		1.00	1.00	18.89	2	37.78
25	Disposal system for size 8 stalks	810	10	81.00	26.73	32.40	140.13	15.00	25.00	40.00	180.13	1	180.13
26	Trash belt, 24-in.×58-ft	1,530	10	153.00	50.49	61.20	264.69	7.50	50.00	57.50	322.19	1	322.19
27	Trash belt, 36-in.×50-ft	1,650	10	165.00	54.45	66.00	285.45	30.00	40.00	70.00	355.45	3	1,066.35
28	Trash belt, 36-in.×80-ft	3,020	10	302.00	99.64	120.80	522.44	60.00	80.00	140.00	662.44	1	662.44
—	Automatic size marker	300	8	37.50	10.13	12.00	59.63		12.00	12.00	71.63	6	429.78
—	Wheel conveyor, 12-in.×10-ft	45	5	9.00	1.62	1.80	12.42		1.00	1.00	13.42	4	53.68
—	Fork truck, 3,000-lb	7,500	7	1,071.43	257.14	300.00	1,628.57	270.00	450.00	720.00	2,348.57	2	4,697.14
	Total cost												94,961.95

[1] Interest based on average investment over the life of the equipment; insurance and taxes based on initial investment.
[2] Based on 1,000 hours annual use.
[3] Based on 3 cents per kilowatt hour for electricity.
[4] Estimated annual costs.

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